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CONTENTS

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UDC 620.1:539.434

EFFECT OF NONUNIFORM STATE OF THERMAL STRESS ON RESISTANCE OF EI826 ALLOY TO THERMAL FATIGUE

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 21 Jun 84) pp 71-75

[Article by G.R. Semenov, Strength Problems Institute, UkSSR Academy of Sciences]

[Abstract] A study of the EI826 heat-resistant Ni alloy for gas-turbine blades was made for the purpose of determining the effect of a nonuniform state of thermal stress on the life of such blades under a load with temperature cycling. Tests were performed on specimens in the shape of wedges, allowing wide-range control of thermal stresses at the edge independently through variation of any of the geometrical dimensions. A stack of 20-25 wedges, forming a multirow two-dimensional array, was tested in the wind tunnel at the Strength Problems Institute in a stream of kerosene combustion products. The temperature of that stream was varied cyclically over the 180-1250°C range with 10 s heating time and 60 s cooling time so as to simulate the start-stop cycles of a gas engine. The temperature field was determined on the basis of the equation of transient-state heat conduction and its solution by the method of finite differences for boundary conditions of the first kind. These boundary conditions for heat transfer were established on the basis of temperature readings under the given heat load. The thermal stresses and their distribution over the height of a wedge were calculated according to the theory of elasticity. Selected as parameters characterizing the thermomechanical load cycle were the maximum temperature, the swing of nominal thermal stresses, and the temperature gradient along the edge. The life of the material was defined in terms of the number of cycles preceding the appearance of a 0.5 mm long principal crack. Regression analysis, after a Bartlett test for reproducibility, has yielded the dependence of the life of this material on those three load cycle parameters, with the relevant statistics. Under given load conditions, failure was found to occur between 300 and 6500 cycles. References 5: 4 Russian, 1 Western (in Russian).

2415/9716
CSO: 1842/35

UDC 546.683:543.432

TURBIDIMETRIC DETERMINATION OF THALLIUM IN SEMICONDUCTOR AND OTHER ALLOYS

Moscow ZAVODSKAYA LABORATORIYA in Russian No 8, Aug 86 (manuscript received 4 Oct 85) pp 3-4

[Article by L.R. Narushkyavichus and A.A. Abrutis, Vilnyus State University imeni V. Kapsukas]

[Abstract] A simple and accurate method of determining thallium in various alloys is proposed, using methylene blue as reagent without extraction of the ionic associate. This turbidimetric method is based on formation of a fine-disperse solid phase $TlBr_4^-$ - MB, where the fraction of MB and the decrease of optical density at the maximum-intensity wavelength for this dye are linearly dependent on the Tl(III) concentration in aqueous solutions. A standard Tl(III) solution of 200 µg/ml is prepared by dissolving 0.1117 g Tl_2O_3 in 20 ml hot 2.5 M H_2SO_4, then diluting with H_2O distillate to 25 µg/ml Tl(III) concentration and acidifying with H_2SO_4 to pH~1. A standard solution can also be prepared with $TlNO_3$, here Tl(I) being acidified with Br-water and excess acidifier being wiped out with 5% solution of hydroxylamine hydrochloride. The calibration curve is a straight line y= 1.28- 0.024x (x- µg Tl in 25 ml solution), with a standard deviation smaller than 0.03, almost the same for both standard solutions. Replacing the $TlBr_4^-$ ion with $TlCl_4^-$ lessens both the sensitivity and the reproducibility of thallium determination, while replacing it with TlI_4^- improves the sensitivity but lessens the reproducibility appreciably. Some error, though smaller than 10%, is introduced by presence of 10,000 times larger quantities of Ca, Cr (III), Fe(III), Co(II), Ni, Cu(II), Zn, Ga(III), As(V), Se(IV), In(III), 5000 times larger quantities of Al, 2000 times larger quantities of Sn(II), and 100 times larger quantities of Sb(V), Hg(II). References 4: all Russian.

2415/9716
CSO: 1842/21

UDC (546.47/.48+546.56):543.42.062

SELECTIVE DETERMINATION OF (Cu,Zn,Cd) CYANIDE COMPLEXES IN ELECTROLYTES BY SPECTROPHOTOMETRIC TITRATION

Moscow ZAVODSKAYA LABORATORIYA in Russian No 8, Aug 86 (manuscript received 3 Jul 85) pp 9-11

[Article by V.V. Kuznetsov, O.A. Korchagina and O.L. Samorukova, Moscow Chemical Technology Institute imeni D.I. Mendeleyev]

[Abstract] Spectrophotometric titration is proposed for determining Cu, Zn, Cd in electrolytic solutions of their cyanides, utilizing the fact that CN^- is an anion and thus an electron donor forming complexes with metal ions. Such complexes are not sufficiently stable in water and, therefore, water-organic solutions are preferred. Titration with solutions of Ba or Sr salts

through formation of much less stable extraspheral complexes $Me(H_2O)_6.M(CN)_4$ (Me= Br,Sr; M= Cu,Zn,Cd) facilitates quantitative analysis not only of individual Cu, Zn, Cd cyanide electrolytes but also of their binary mixtures. It can be performed in an SF-6 spectrophotometer with a stirrer and a photoelectrocolorimeter vessel. References 10: 9 Russian, 1 Western.

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CSO: 1842/21

UDC 546.821:543.253

POLAROGRAPHIC DETERMINATION OF Ti IN Ni POWDERS

Moscow ZAVODSKAYA LABORATORIYA in Russian No 8, Aug 86 (manuscript received 11 Jun 85) pp 13-14

[Article by I.B. Voronina and A.K. Kirokasyan, All-Union Current Sources Scientific Research Institute, Moscow]

[Abstract] A modification of the polarographic method is proposed for faster and sufficiently precise determination of Ti in catalytic Ni powders containing also Mg, Al, Cr, Mn, Co, Cu. It does not require separation of Ni and the other elements and involves a.c. polarography of a complex formed by Ti(IV) oxalate at pH 1. It is based on the linear dependence of the magnitude of the Ti peak on the Ti concentration over the $1 \cdot 10^{-4}$-$8 \cdot 10^{-2}$ mg/ml range in a mixture of 4% $(COOH)_2$+ 0.72 M H_2SO_4. The correctness of this method has been verified on specimens of Ni powder with Ti and various combinations of two or three of the other alloying elements. References 7: 5 Russian, 2 Western.

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CSO: 1842/21

UDC 546.712/714:543.21

DETERMINATION OF MnO AND MnO_2 IN MANGANESE ORES

Moscow ZAVODSKAYA LABORATORIYA in Russian No 8, Aug 86 (manuscript received 28 Mar 85) pp 15-17

[Article by A.S. Rylkova, V.V. Cherevik and L. Ye. Samborskaya, Scientific Research Institute of Mechanical Processing of Useful Minerals for Ferrous Metallurgy (NII Merchanobrchermet, Krivoy Rog]

[Abstract] Determination of MnO and MnO_2 in manganese ores has been found to be most accurate when based on dissolution of MnO in dilute (1 M) H_2SO_4, with MnO_2 remaining in the residue. The presence of Mg, Al, Ca, Fe(III), Ba in these ores does not influence the selectivity with regard to dissolution of Mn(II) and precipitation of Mn(IV). The method is more accurate than calculation of the MnO content from the difference between total Mn content and Mn content in MnO_2. It is also yields more accurate and better reproducible results than use of oxalic acid or volumetric determination, as

has been demonstrated on specimens of Chiatursak and Nikopol ores (manganite, psilomelane, pyrolusite, rhodochrosite). Thermal differential analysis and thermogravimetric analysis as well as x-ray structural examination before and after treatment with 1 M H_2SO_4 for 2 h revealed no significant changes except small ones attributable to the endothermic effect. References 5: all Russian.

2415/9716
CSO: 1842/21

UDC 621.382.232

CHEMICAL ANALYSIS OF SUBSURFACE REGION IN $Pb_{0.8}Sn_{0.2}Te$ SINGLE CYRSTALS DOPED BY LASER TREATMENT

Moscow ZAVODSKAYA LABORATORIYA in Russian No 8, Aug 86 (manuscript received 17 Jun 85) pp 30-32

[Article by Ye.A. Gorin, O.S. Ivanova, A.V. Shchukarev and G.I. Yanko]

[Abstract] Single crystals of binary telluride 80 vol.% PbTe + 20 vol.% SnTe were electrochemically or vacuum coated with 0.02-0.04 μm thick films of Au or Cu and subsequently treated with radiation from a glass:Nd^{3+} laser in one pulse (Au) or in four successive equal pulses (Cu) of 0.2-0.8 J/cm^2 energy and 100 ns duration. Quantitative analysis of their region from the surface to a depth of 0.2 μm (with Au) or beyond 5 μm (with Cu) was then performed by the method of photoelectron spectroscopy in a VG Scientific ESCALAB-5 apparatus, with layerwise etching at a rate of 10-30 Å/min by means of an Ar-ion beam. Calculations based on the relative intensities of spectral lines have yielded the depthwise profiles of Pb, Sn, Te, and dopant (Au or Cu) concentration in atom.%, indicating a dependence of the dopant penetration depth on the laser pulse energy up to a saturation level. Anomalies appearing along these profiles correspond to varying degrees of recrystallization and, at a depth of about 0.1 μm (Au, 0.3 J/cm^2 laser pulse) or 10 μm (Cu, 0.5 J/cm^2 laser pulses), to eventual expulsion of oxygen and a much steeper decrease of dopant. References 5: 3 Russian, 2 Western.

2415/9716
CSO: 1842/21

UDC 620.179.14

INFLUENCE OF PHYSICAL DIFFERENCES BETWEEN BARKHAUSEN EFFECT AND BARKHAUSEN ACOUSTIC EMISSION ON THEIR APPLICABILITY TO NONDESTRUCTIVE INSPECTION

Sverdlovsk DEFEKTOSKOPIYA in Russian No 9, Sep 86 (manuscript received 2 Aug 84, in final version 2 Jan 86) pp 3-17

[Article by V.G. Kuleyev, V.Ye. Shcherbinin, S.V. Zhakov, Yu.S. Subbotin and N.M. Menshikov, Metal Physics Institute, Ural Science Center, USSR Academy of Sciences]

[Abstract] The physical differences between the Barkhausen effect and Barkhausen acoustic emission are reviewed from the standpoint of the

applicability of both phenomena to nondestructive inspection of ferromagnetics. One fundamental difference is that the Barkhausen effect is produced by jumps of 180° and 90° domain walls, while Barkhausen acoustic emission is produced by jumps of 90° domain walls only. A comprehensive theoretical analysis, with potential barriers taken into account as an essential determining factor, and analysis of experimental evidence reveals that the Barkhausen effect involves emission of only transverse electromagnetic waves, while Barkhausen acoustic emission includes transverse and longitudinal elastic waves. Barkhausen acoustic emission is subject to the Doppler effect, but the Barkhausen effect, confined to a thin skin layer only with the skin depth varying during a period of the alternating magnetizing field, is not. The skin effect also differently influences the Barkhausen effect and Barkhausen acoustic emission. It influences the Barkhausen effect only as a consequence of the dynamic magnetic permeability being a function of time, while Barkhausen acoustic emission is influenced by it because of different amplitudes of the magnetic field in different layers of the ferromagnetic material and because of a different timing of signal from different layers. Nonuniformity of the internal magnetic field affects only Barkhausen acoustic emission, not the Barkhausen effect. Important factors are also the different frequency spectra of the two phenomena and the different dependence of each on the amplitude of the magnetic field, this dependence being notably different at different frequencies in the case of Barkhausen acoustic emission. References 22: 6 Russian, 16 Western.

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THEORY OF OVERHAND TRANSDUCERS WITH SHORT COILS

Sverdlovsk DEFEKTOSKOPIYA in Russian No 9, Sep 86 (manuscript received 24 Oct 85) pp 17-22

[Article by B.V. Goncharov, Scientific-Industrial Association Central Scientific Research Institute of Machine-Building Technology]

[Abstract] The problem of electromagnetic coupling between a flat inspection object made of an electrical conductor material and the measuring coil of an overhand eddy-current transducer is solved analytically, in an approximation sufficiently close to include the dependence of insertion parameters on variations of the clearance. The integral equation for the insertion voltage in the measuring coil, a fundamental equation in the theory of such transducers, is solved for a transducer with two coils in a coaxial configuration. Both the excitation coil and the measuring coil are reduced in length to a single turn, whereupon the equivalent radius of each is calculated. The inspection piece, ideally a half-space and really a plate, is assumed to be made of a nonmagnetic electrically conducting material. An accuracy analysis of the solution yields the inspection error and the necessary correction. The theory of designing such transducers is, on this basis, extended to transducer coils of arbitrary length and to inspection of multilayer objects. References 7: all Russian.

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STABILITY OF RESIDUAL MAGNETIZATION STATE OF VARIOUSLY HEAT-TREATED STEELS IN CONSTANT DEMAGNETIZING FIELDS

Sverdlovsk DEFEKTOSKOPIYA in Russian No 9, Sep 86 (manuscript received 2 Jul 85, in final version 16 Jan 86) pp 23-32

[Article by E.S. Gorkunov, V.M. Somova and N.B. Buldakova, Physical Technical Institute, Ural Science Center, USSR Academy of Sciences, Ustinov]

[Abstract] An experimental study of three structural steels (34CrNi3Mo, $60Si2N_2$, U8A shock-resistant) was made, for inspection purposes on the basis of the residual magnetization and its stability in a constant demagnetizing field as a reliable indicator of the structural state depending on the mode of heat treatment. Specimens of all three steels, two dimensional variants of rings and four dimensional variants of rectangular bars, were heated in a tubular electrical laboratory furnace and held for 20 min at the final termperature: 850°C (34CrNi3Mo, U8A) or 870°C ($60Si2N_2$). They were quenched from the respective temperatures in oil to room temperature and then tempered at temperatures from 100°C to 700°C, for 1.5 h ($60Si2N_2$, U8A) or 2 h (34CrNi3Mo) with subsequent air cooling to room temperature. Following this heat treatment, the specimens were magnetized by a direct current from a special generator, letting the current smoothly increase and decrease at the appropriate rate. Measurements were made with an F190 microwebermeter, an F30 digital voltmeter, and an N306 magnetization curve plotter. Measurements of the remanence, after partial demagnetization along the hysteresis curve, as a function of the magnetizing field intensity and as a function of the tempering temperature have revealed that its stability and sensitivity to a demagnetizing field depend on the structural state of the steel as well as on the magnitude of the demagnetization factor. The dependence of the remanence on the tempering temperature was found not to be qualitatively different after partial demagnetization than after full demagnetization. References 9: 8 Russian, 1 Western.

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DEPENDENCE OF SPECTRAL CHARACTERISTICS OF ACOUSTIC EMISSION SIGNALS ON AMPLITUDE-FREQUENCY CHARACTERISTIC OF INSPECTION PIECE

Sverdlovsk DEFEKTOSKOPIYA in Russian No 9, Sep 86 (manuscript received 4 Jun 85) pp 39-45

[Article by A.I. Gorbunov and Yu.I. Lykov, Dalstandart Scientific-Production Association, Khabarovsk]

[Abstract] The spectrum of acoustic emission signals from an inspection piece, a thin elastic rod, is calculated theoretically with not only the

amplitude-frequency characteristic of the transducer but also that of the rod taken into account. Inasmuch as the latter depends not only on the length of the rod but also on the location of the signal source, calculations are facilitated by averaging it over typically 10 kHz wide frequency intervals. For an accuracy analysis, the results of such calculations for a metal rod, either with one transducer or between two transducers, are compared with calculations made without averaging and with experimental results. The effect of the nonuniformity of a rod's amplitude-frequency characteristic on the spectral characteristics of acoustic emission signals during inspection is found to be abatable by various means such as using a longer rod and averaging its amplitude-frequency characteristic, insertion of additional damping between rod and transducer, loading the rod at both ends with matched absorbers, and ensuring that acoustic emission signals will be generated either at the ends or near the center of the rod. References 7: 5 Russian, 2 Western.

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SELECTION OF BEAM LEAD-IN ANGLE FOR ULTRASONIC INSPECTION OF WELDED JOINTS

Sverdlovsk DEFEKTOSKOPIYA in Russian No 9, Sep 86 (manuscript received 27 Feb 84, in final version 4 Jul 85) pp 86-88

[Article by L.I. Kuzmina, Scientific Research Institute of Bridges, Leningrad Institute of Railroad Transportation Engineers imeni Academician V.N. Obraztsov]

[Abstract] Probing of welded joints with ultrasonic waves by either longitudinal-transverse or transverse-longitudinal scanning for flaw detection is considered, the forward beam probing the lower half and the once reflected beam probing the upper half of the seam. The problem is to determine the respective beam lead-in angles ensuring coverage of the entire seam cross-section by the acoustic axis. The problem is analyzed and solved on the basis of geometrical relations, specifically for a straight seam joining two equally thick plates along their edges and either one movable ultrasonic transducer or two of them on one plate. Interference immunity is disregarded as a factor. In the general case of the two lead-in angles unequal probing is done sequentially, with two transducers, and most conveniently with the two angles smallest possible. In the case of the two lead-in angles equal probing is done most effectively with one transducer.

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INSPECTION OF 20Mn1V AND 20V CAST STEELS FOR MECHANICAL CHARACTERISTICS BY MAGNETIC METHOD

Sverdlovsk DEFEKTOSKOPIYA in Russian No 9, Sep 86 (manuscript received 14 Aug 85, in final version 5 Mar 86) pp 90-92

[Article by I.A. Vays, Yu.P. Bashkirov, Ye.D. Sakovich, A.E. Ivanskiy, G.V. Bida and V.Ye. Strelyanov (deceased), Uralvagonzavod imeni F.E. Dzerzhinskiy Production Association and Metal Physics Institute, Ural Science Center, USSR Academy of Sciences]

[Abstract] Two cast steels for railroad cars, 20Mn1V and 20V (both normalized at 930°C), were inspected upon delivery for mechanical characteristics by the magnetic method. Measurements were made with a KIFM-1 coercimeter, after calibration against a single tensile-rupture specimen of each steel and readings of the demagnetizing current during that mechanical test. Over 1000 ingots of each steel were sampled from production runs for a period of over half a year. The data were statistically adequate for establishing, by the least squares method, regression equations relating the mechanical properties (yield strength, ultimate tensile strength, percentage elongation, percentage reduction, impact strength of 20Mn1V steel at -60°C, impact strength of 20V steel at +20°C) along with respective standard deviations and correlation coefficients at a 0.95 or higher confidence level. In addition quadratic equations were established relating the mechanical properties to the coercimeter demagnetizing current and linear multivariate regression equations taking into account the chemical composition of each steel in the ladle. This method of nondestructive inspection can now replace the much more laborious method of direct mechanical testing. The authors thank A.A. Lifshitz for assistance in processing the statistical data and L.I. Kosarev for collaborating in development of the inspection procedure. References 4: all Russian.

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UDC 541.183

DEPENDENCE OF STRUCTURE OF CERTAIN METAL OXIDES OF METHOD OF PRODUCING THEM

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 8 Feb 85) pp 1679-1682

[Article by N.E. Bolotina, S.M. Rakhovskaya, I.Ya. Gvozdyukov and G.V. Gvozdyukova, Saratov State University imeni N.G. Chernyshevskiy and Scientific Research Institute of Chemistry]

[Abstract] For a comparative evaluation of various methods of producing porous oxides of transition metals, oxides of three such metals (NiO, CoO, Co_3O_4, CdO) were produced by thermal decomposition of their hydroxides and

nitrates. Hydroxides $Ni(OH)_2$, $Co(OH)_2$, $Cd(OH)_2$ were dehydrated in air at temperatures of 300°C, 200°C, 250°C respectively or under vacuum at temperatures of 250°C, 120°C, 200°C respectively, for 10 h in each case. Nitrates were calcined at 350°C, 270°C, 420°C respectively by the method used for producing catalytic or sorbent oxide sponge. Structural examination of the products include: measuring the total volume and, with a mercury porometer, the radius of pores of the dominant size fraction; measuring the specific surface area by the nitrogen low-temperature absorption method; measuring the dimensions of coherently radiation-scattering crystallites in a DRON-2 x-ray diffractometer with FeK_α-radiation source and Mn filter; estimating the oxide grain dimensions without available perfectly crystallized etalon materials; and plotting the 25°C isotherms of water-vapor adsorption in a vacuum apparatus with quartz spring scales with a 3 mg/mm sensitivity. These isotherms were compared with water adsorption isotherms of the corresponding hydroxides and found to have anomalous hysteresis loops with a irreversibility increasing in the order $irr_{NiO} < irr_{CoO} < irr_{CdO}$. The irreversibility is attributable to penetration of not easily desorbable water molecules (approximate size 3 Å) into the smallest cracks and pores of the NiO structure, to their penetration and subsequent slight chemosorption in the CoO structure with its attendant dehydroxidation, and to their intense chemosorption in the CdO structure with attendant formation of the γ-$Cd(OH)_2$ phase. References 12: 11 Russian, 1 Western.

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CSO: 1842/32

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DETECTING FLAWS IN BUTT-WELDED JOINTS WHEN STRAIGHTENING PRODUCTS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 26 May 86) pp 69-72

[Article by V.I. Petrov, V.A. Kuznetsova and N.A. Chelyshev, Siberian Metallurgical Institute]

[Abstract] Research was done on how to develop a method for detecting welding seam flaws from acoustical signals during static loading of a product, i.e., during straightening. Welded joints of R6M5 and U7 steel rods 12 to 16 mm in diameter were studied. Some speciemns had no defects; the others had predetermined defects. The signals were recorded by a wide-range instrument, with the acoustical emission activity recorded by an Endim 620.02 plotting device and the summated acoustical emission converted to numerical form. The specimens were subjected to three-point bending on an R-50 machine; maximum stress did not exceed $0.7\sigma_y$. Using the test results, time dependencies for load, emission activity, and summated emission were obtained for both the sound and defective specimens. The defective specimens fractured at loads much lower than $0.7\sigma_y$, their summated acoustical emission was an order of magnitude greater than that of the sound specimens, and they had a higher signal activity. Some fractures showed zones of incomplete fusion. Those fractures that had no such zones were attributed to irregularities in the structure of the steels. In any event, the defects were revealed through acoustical emission, which

proved to be quite sensitive in the detection of defective butt-welded joints. The method described can be used to quickly analyze these types of joints for defects as the products are being straightened.

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CAUSES IN CONCHOIDAL FRACTURES IN 15Kh2M2FBS HEAT-RESISTANT STEEL CASTINGS USED IN TURBINES

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 14 Mar 85) pp 88-91

[Article by V.P. Tarabanova, S.S. Dyachenko, and L.D. Mishchenko, Kharkov Highway Institute]

[Abstract] The interrelationship between the structural changes, conchoidal fractures, and impact strength in steel used for castings subjected to long-term thermal and mechanical stresses was studied. The body of a steam-valve assembly was taken from a K-300-240 turbine after 100,000 hours of operation at the Predneprovskaya State Regional Power Plant. This body was cast from heat-resistant 15Kh2M2FBS steel. Grain size was determined by uniformly examining a section of not less than 200 grains, magnified 100 times. The fractures were studied using two-stage reproductions on an UEMV-100K electron microscope. Impact strength was determined at room temperature per State Standard 9454--78. During turbine operation, the carbides recrystallized and coalesced. As a result, the baynite dissociated into a ferrite-carbide mixture, and ferritic sections were isolated between large ferrite-carbide or baynite grains. This change in the structure of the steel is primarily responsible for the severe drop in impact strength. The appearance of conchoidal fractures, which are a special problem with this steel, was associated with large grain size and with the filling of grain-boundary cavities with unidentified, probably sulfide, inclusions. It was also determined that conchoidal fractures are not exclusively accompanied by brittle failure; there was also a high percentage of conchoidal fractures that were ductile in nature. References: 3 Russian.

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EFFECT OF PROTECTIVE COATINGS ON HIGH-TEMPERATURE FATIGUE OF HEAT-RESISTANT ALLOYS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 22 Aug 84) pp 76-78

[Article by Yu.G. Veksler, V.V. Gribov, V.P. Lesnikov, A.A. Rabinovich, G.F. Myalnitsa and O.G. Zhiritskiy, Ural Polytechnical Institute, Sverdlovsk]

[Abstract] The effect of protective coatings on the resistance of heat-resistant alloys to high-temperature fatigue was studied using the EP539LM alloy for gas-turbine engines with an Al-Nb-Si dross coating and also with a Co-Cr-Al-Y electron-beam coating. Tests were performed on bar specimens with two symmetrically opposite 60° V-notches at the center, these bars being fixed at one end and free at the other in cantilever fashion. They were loaded in symmetrically alternating flexure at a frequency of 50 Hz at a temperature of 900°C. They were tested under vacuum and in air for determination of the effect of an oxidizing medium on the fatigue kinetics. Specimens without coating were tested, after standard heat treatment or heat treatments corresponding to dross deposition and electron-beam deposition of coatings respectively, and then specimens with coatings were tested. Coatings were found to lower the fatigue resistance at 900°C both in air and under vacuum, a Co-Cr-Al-Y coating less than an Al-Nb-Si coating. An analysis of various possible factors influencing this detrimental effect indicates that properties of the coating material determine it, a more plastic coating having a less detrimental effect, but that the mechanisms are different in air and under vacuum. Vacuum stimulates evaporation of alloying elements and formation of a soft γ'-phase layer. Air at high temperature stimulates both formation of hard oxide surface films, which are protective but not plastic, and internal oxidation. References: 7 Russian.

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ALUMINUM CONDENSATES PRODUCED BY ION-BEAM SPUTTERING UNDER VACUUM

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 10 Nov 85) pp 83-86

[Article by L.S. Palatnik, V.A. Dudkin, V.Ye. Pukha and A.S. Vus, Kharkov]

[Abstract] In an experimental study aluminum condensate films were deposited on NaCl substrates by sputtering a water-cooled Al target 60 mm in diameter with a plasma stream of a vacuum-discharge arc for the purpose of determining the dependence of both their structure and orientation on the composition of the condensing stream. The plasma was emitted by the arc generating cathode and impinged on the target at a 30° angle to its surface, a negative voltage of -600 V having been applied to that target, a vacuum of 10^{-4} Pa in the evaporator chamber with metal seals having been generated by an "Orbitron" hetero-ion pump, and the substrates having been heated to 200°C. Microstructural examination of 0.5 um thick films under a microscope and with an electron diffractometer revealed films similar to those produced on NaCl substrates "in air", without macrocrystalline inclusions. Those obtained from a stream of Al atoms and ions without electrons were polycrystalline with (111) Al $\|$ (100) NaCl orientation. Those obtained from a stream of Al atoms and ions with electrons, of the complete substance, were monocrystalline with (100) Al $\|$ (100) NaCl orientation and with characteristic 10 mm wide channels. References 4: 3 Russian, 1 Western (in Russian translation).

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CRYSTALLINE STRUCTURE AND MECHANICAL EROSION OF Mo CONTACT COATINGS DEPOSITED FROM PLASMA OF VACUUM-DISCHARGE ARC

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 28 May 85) pp 87-91

[Article by G.Sh. Mangutov, B.M. Shafin, Ye.F. Smyslov, V.V. Felmetsger, and M.G. Erlikhson, Ryazan]

[Abstract] An experimental study of Mo coatings deposited from a vacuum-discharge plasma on contact surfaces of switching devices was made for the purpose of establishing the relation between characteristics of their crystalline structure and their mechanical erosion. Coatings were deposited on Permalloy substrates with a plasma accelerator under a vacuum of 10^{-2}-10^{-3} Pa after the substrates had been annealed in hydrogen and pretreated with a beam of 10^3 eV Mo ions at a current density of 300-500 A/m^2 for 1-2 min, the surface roughness of these substrates being within the $R_a \simeq 0.16$-0.65 um range. The arc cathode was made of molybdenum with not more than 0.003% C. The arc current was varied over the 80-220 A range and the substrate potential was

varied over the 0-(-70) V range. Structural examination of the coatings was done by Auger spectroscopy, under an REM-200 scanning electron microscope with a fractograph, and in a DRON-3 x-ray diffractometer for phase analysis. The examination revealed coatings with a fine-disperse lower layer under a columnar upper layer responsible for instability of the electrical contact resistance. Its brittle fracture was found to be both transcrystalline and intercrystalline, the brittleness temperature for each mode depending differently on the carbon content. The transcrystalline brittleness temperature increases monotonically, at a decreasing rate, as the carbon content increases. The intercrystalline brittleness temperature oscillates with increasing carbon content: in the low-carbon range it increases owing to segregation of interstitial impurities at grain boundaries, it then decreases owing to precipitation of fine-disperse Mo carbides at grain boundaries, and in the high-carbon range it again increases owing to formation of brittle continuous impurity interlayers. The cold shortness of such coatings can be avoided, though not completely, by controlling the deposition process so as to minimize the transverse dimensions of those columnar grains and thus lowering the brittleness temperature or by lowering the impurity and particularly carbon content. References: 7 Russian.

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UDC 669.295'786

STRUCTURAL CHANGES in TiN COATINGS DURING SMOOTHING WITH DIAMOND TOOL

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 14 Oct 85) pp 111-114

[Article by L.A. Khvorostukhin, L.I. Belykh, L.I. Kuksenova, L.M. Rybakova and A.Ye. Bolmanenkov, Moscow]

[Abstract] A study of TiN coatings produced on WTi9 and WTi20 alloys by condensation under ion bombardment and subsequent smoothing with a diamond tool was made for quality control purposes. Cylinders of these two Ti alloys, 10 mm in diameter and 50 mm long, were bombarded with Ti ions form a pure titanium target in a nitrogen atmosphere. One base of a coated cylinder was treated with a diamond tool, its tip having a radius of 2.5 mm, the cylinder rotating at a speed of 125 rpm and the tool pressing with a force of 100 N while moving axially at a rate of 0.05 mm per cylinder revolution. Microstructural examination of 1.5 mm thick cylindrical segments with 10^{-3}-10^{-5} mm thick coatings was done, before and after mechanical treatment with the diamond tool, in a cylindrical RKD x-ray reflection diffractometer with CoK_0-radiation source. A sliding x-ray beam was used, at 1-20° angle to the specimen surface, and the width of diffraction lines was measured with an MF-4 microphotometer. The coatings were tested for wear resistance on a 10.7 km base in a 77MT-1 reciprocating friction machine under a load of 4 MPa, against KhM cast iron with a ground surface in kerosene. The wear was measured, after every 1.7 km of travel, by the weighing method on a VLA-200M analytical balance within 0.1 mg accuracy. The microhardness was measured on a PMT-3 tester with a 50 g indenter. The results indicate that structurization

of TiN coatings under a diamond tool depends not only on parameters of this treatment and of the prior condensation process but also on the chemical composition and the structure of the substrate material. The process is controllable and optimizable for maximum wear resistance of coatings, but has been found to be more effective for the WTi20 alloy than for the WTi9 alloy. References: 5 Russian.

2415/9716
CSO: 1842/39

UDC 534.26+539.374

PHENOMENOLOGICAL PIERCING CHARACTERISTICS OF COMPOSITE MATERIALS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 27 Feb 84) pp 62-66

[Article by V.P. Muzychenko, Daugavpils, and V.I. Postnov, Kuybyshev]

[Abstract] The piercing characteristics of several nonmetallic composite materials, as well as of Ti alloys WTi20 and OTi-4-1, are analyzed from the phenomenological standpoint on the basis of experimental data pertaining to barriers made of these materials subject to impact by high-speed indenters. The composite materials tested include KSTE glass cloth with 20-30% epoxy binder, KST glass mats without binder, KSVF glass fiber AG-4"v" with fluorocarbon filler, and alternate layers of glass cloth and carbon tape with epoxy-triphenol binder. The data have been processed so as to reveal the functional dependence of critical indenter velocity v_c, its entrance velocity and exit velocity, as well as the difference between them or the velocity drop, normalized to the critical velocity, on the product of barrier thickness h and barrier material density ρ_b. Additional factors considered are ratio of barrier thickness h to indenter diameter d and ratio of indenter material density ρ_i to barrier material density ρ_b. Universal curve plotted on the basis of these data and comparison with analogous curves for AlMgo aluminum alloy, M4 copper, also Ni, In, Sn alloys, indicate similar trends in the postcritical range. Specifically, the $h/d - \frac{v_c}{c}\sqrt{\rho_i/\rho_b}$ curves (c- speed of sound in barrier material) are straight lines for all these materials. They also indicate that glass mats have a higher resistance to piercing than other glass plastics and glass-carbon composite, while the residual strength of glass cloth with epoxy binder drops more than that of other composites over the entire range of high-speed impact velocity. References 12: 5 Russian, 7 Western (1 in Russian translation).

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CSO: 1842/35

UDC 620.194

REDUCTION OF ENDURANCE LIMIT OF STEEL IN MEDIA CONTAINING H_2S

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 4, Jul-Aug 86 (manuscript received 23 Jul 85) pp 19-22

[Article by B.I. Kultan, Ya.M. Sirak and I.I. Vasilenko, Physical-Mechanical Institute imeni G.V. Karpenko, UkSSR Academy of Sciences, Lvov]

[Abstract] An experimental study of annealed 40Cr steel in a medium containing H_2S was made, for the purpose of determining the effect of such a medium on fatigue and corrosion. Smooth cylindrical specimens 5 mm in diameter and cylindrical specimens 60 mm in diameter with 8 mm deep 60° V-form grooves were tested in cyclic flexure by rotation at a speed of 3000 rpm, some in NACE (5% NaCl + 0.5% CH_3COOH + 94.5% H_2O), some in benzene H_2S saturated and some in plain aqueous 3% NaCl solution. For reference, specimens with grooves were subjected to 10^5 stress cycles at 100 MPa level in air. The results reveal an 8-10% lower endurance limit in H_2S-saturated benzine and a 66-75% lower endurance limit in 3% NaCl solution without hydrogenation of steel. This indicates intense hydrogenation of steel in a medium with H_2S which accelerates growth of fatigue cracks in large specimens under a cyclic load even at a frequency as high as 50 Hz, while 3% NaCl solution inhibits fatigue cracking. References 13: 9 Russian, 4 Western.

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CSO: 1842/23

UDC 539.27

DEPENDENCE OF HYDROGEN EMBRITTLEMENT OF AUSTENITIC STAINLESS STEELS ON STRUCTURAL STATE OF GRAIN BOUNDARIES

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 4, Jul-Aug 86 (manuscript received 11 May 85) pp 23-26

[Article by P.A. Platonov, Yu.R. Kevorkyan and I.Ye. Tursunov, USSR State Committee for Utilization of Atomic Energy]

[Abstract] An experimental study of hydrogen embrittlement of OCr16Ni15Mo3Nb steel was made for the purpose of determining its dependence on the structural

state of grain boundaries. Tests were performed on flat specimens without any treatment; annealed at 1323 K for 30 min and quenched in water; annealed at 923 K for 0.5 h, 3 h, 6 h, 12 h and 24 h; or aged at 523 K with 1.2% and 5.5% residual strain. Each treatment affects the grain boundaries differently, preliminary annealing being known to cause precipitation of $Me_{23}C_6$ metal carbides at grain boundaries. All specimens were electrolytically hydrogenated in aqueous solution of 4% H_2SO_4 + 5 mg/l As_2O_3 at a current density of 500 A/m^2 at a temperature of 353 K for 4 h, with a platinum anode. Following this treatment, the specimens were tested mechanically in an "Instron-1195" machine at a deformation rate of 20 mm/min at room temperature and 150 um thick slices were examined under a "Temscan-100C*" electron microscope. The hydrogen content in specimens after fracture and subsequent aging at room temperature for 24 h was measured in a "Leco" analyzer. Hydrogenation was found to alter the mechanical characteristics of all specimens, to raise the 0.2% yield point by approximtely 50% and to first increase but then decrease hydrogen embrittlement. Reversibility of hydrogen enbrittlement was found to be almost complete in raw specimens and only partial in annealed ones. This dependence of hydrogen embrittlement on the length of prior annealing treatment, its irreversibility increasing when specimens have been annealed for a longer period of time, is attributable to morphological changes at grain boundaries and particularly a buildup of carbides which precipitate during annealing and then act as hydrogen traps. The authors thank A.D. Amayev, K.P. Dubrovin, and G.P. Sayenko for discussion and valuable comments and K.V. Gorskiy, O.V. Lavrenchuk, and V.N. Perevezentsev for assistance in the experiment. References 10: 4 Russian, 6 Western (1 in Russian translation).

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CSO: 1842/23

PRAVDA VIEWS METALLURGY PROBLEMS, TASKS

Moscow PRAVDA in Russian 13 Nov 86 p 1

[Editorial: "Metallurgical Industry Reserves"]

[Text] All national economic sectors need metal. And not simply metal, but a wide range of rolled metal with special properties specified in advance. The demands on the quality of metal are rising steadily. It will only be possible to satisfy them fully if modern standards are ensured in the metallurgical industry on the basis of the achievements of science and technology and the most progressive production processes. The vast program for the renewal of fixed capital in ferrous metallurgy to be implemented in the 12th 5-Year Plan has been conceived with this aim in mind.

How is reconstruction progressing in this key sector of the national economy? Many examples of excellent work in the retooling of shops and enterprises could be cited. Thus, for instance, the renewal of the electric pipe welding shop at the Khartsyzsk Pipe Plant was carried out at a considerably reduced cost, which has made it possible to produce 1.5 million metric tons of large-diameter pipes for main gas pipelines. Specialists at the Kachkanar Mining and Enrichment Combine, in cooperation with Uralmash specialists, have found an effective solution for the reconstruction of the existing pelletizing factory, which has made it possible to halve the cost of construction and to considerably increase output with the same number of staff. The reconstruction of a billet mill at the Krasnyy Oktyabr Metallurgical Plant in Volgograd has been skillfully organized. It is hoped here to reduce the original estimated cost of the operation by 60 percent.

At the same time, signals have been received at the PRAVDA editorial office indicating that at some of the sector's enterprises reconstruction is proceeding at a slow pace. Work on the retooling of the Kuznetsk Metallurgical Combine, for instance, is taking a long time to get started. Construction workers remain reluctant to tackle the reconstruction of existing shops, which calls for precise work, organization, and strict observance of the set timetables. "Two years ago," P. Dolya, a team leader at the Dneprospetsstal Plant, writes in his letter to the editorial office, "construction started of a new installation in our No. 2 steel smelting shop. This has brought the usual inconvenience and difficulties for those who work here, of course. This would not be so bad, but the construction and installation workers are constantly

failing to meet their deadlines. They do not care about our difficulties... And the situation is no better at many other reconstruction projects at our enterprise." Cases like this have to be subjected to a principled assessment.

Party committees at local level can and must seriously influence the acceleration of the renewal in ferrous metallurgy. The practical experience of the Chelyabinsk, Sverdlovsk, and other party obkoms bears this out. The Chelyabinsk Obkom, for instance, in cooperation with representatives of the ministries and departments, has subjected the progress of the reconstruction of the Magnitogorsk Metallurgical Combine to detailed analysis. Important measures to accelerate the process were outlined. As a result, construction workers were able to identify reserves for accelerating their work and it also proved possible to resolve certain interdepartmental problems. However, party committees do not always and everywhere make the necessary demands on economic managers and closely monitor the fulfillment of the set plans. It would do no harm to the Kemerovo CPSU Obkom, for instance, to learn a lesson from its Chelyabinsk counterpart; after all, there are no fewer problems in the retooling of the oblast's metallurgical enterprises than there are in the central and southern Urals.

At the stage of extensive reconstruction, the main partner of the metal workers are the machine builders. Unfortunately, much of the production equipment which they supply is still inferior to similar foreign equipment in terms of metal consumption, reliability, level of mechanization and automation, unit consumption of lubricants and spare parts, and productivity per worker. There is a shortage of reliable automatic control systems, certain types of hydraulic equipment, and electric motors. Many enterprises of the Ministry of Heavy and Transport Machine Building, the Ministry of the Machine Tool and Tool Building Industry, the Ministry of Power Machine Building, the Ministry of the Electrical Equipment Industry, and the Ministry of Instrument Making, Automation Equipment, and Control Systems are in arrears with their deliveries to metal workers. One of the reasons for this is that the machine building ministries as a rule only embark on the development of new types of equipment after they have received the appropriate funds. Meanwhile it is necessary to work continuously on advanced designs, laying the groundwork in the research and development of new machinery.

The USSR Ministry of Ferrous Metallurgy has adopted a number of organizational measures to establish closer contacts with the creators of new equipment and is monitoring more closely the quality of designs. More than 300 technical projects have been drawn up with respect to basic types of equipment alone. What is alarming, however, is the attempts of machine builders to defend their right to work in the old way, rather than keeping abreast of present-day demands. Specialits at the Staro-kramatorskiy Machine Building Plant, for instance, have acted in this way. Having examined a technical project for producing new units for the Taganrog Metallurgical Plant and the Novomoskovsk Pipe Plant, they proposed uninteresting equipment along the lines of that which has been in use for decades and has essentially exhausted its potential. What is this if it is not lack of courage in engineering thought which condemns us to backwardness?

Such an approach to an important nationwide test is impermissible. After all, even today the lag of the metallurgical industry is affecting other sectors. If we do not ensure a drastic improvement in the quality of metallurgical industry output, if the range of goods it produces does not meet present-day and future requirements, then we will be unable to achieve the necessary breakthrough in machine building as well as in the construction industry and other spheres of the national economy. It is impermissible to put departmental interests first by force of habit and thus to cut the ground from under your own feet. Metallurgy specialists and the designers of new equipment for this sector must start thinking now about the equipment with which we will enter the next century. It is important to ensure that everything valuable that comes to light within the walls of our research and design institutes receives not only verbal but actual and timely backing and mass application at all the concerned enterprises.

Of late, ferrous metallurgy has achieved certain success in its development and in the improvement of its efficiency. In analyzing enterprises' performance and discussing the problems of the sector's retooling, the USSR Ministry of Ferrous Metallurgy is increasingly drawing attention to ways of cutting the prime cost of output, improving cost efficiency, and achieving higher profits. This is correct and in keeping with the times. But there also remain quite a few reserves which can be exploited more fully without additional capital investments. These include the establishment of order in shops, the reinforcement of labor and production discipline, and the mastering of new methods and conditions of management. Now, in the final stage of the first year of the 5-year plan, all these questions must be at the focus of attention of party committees, economic managers, public organizations, and labor collectives.

Improved planning and production organizations, the development on a mass scale of the nationwide competition to greet the 70th anniversary of Great October in a worthy fashion, and day-to-day shock labor--this is the guarantee of the successful fulfillment by metal workers of the great tasks set by the 27th CPSU Congress.

/9716
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USE OF FLAT-ROLLED PRODUCTS INSTEAD OF CASTINGS TO REDUCE CONSUMPTION OF STEEL IN MACHINEBUILDING

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 5 Dec 86 p 1

[Article by I. Pashko, distinguished metallurgist of the RSFSR, doctor of economic sciences: "Paradoxes of Spare Metal"; first paragraph printed in boldface in original]

[Text] In our country the annual per capita production of steel is 570 kg. This figure is probably higher only in the U.S.A. and in Japan. But still there is a shortage of steel in the national economy as a whole and in each individual industry. The demand for steel increases from year to year, and if some extraordinary measures are not taken now, the shortage can become really severe. Many scientists consider the situation that has developed in recent years in steel production to be critical. Are there real possibilities of getting out of this situation? How can this be done? By what means?

It is customary among steel producers to look for reserves. Short of microscopic examination, they have been analyzed from various angles in the press, including in SOTSIALISTICHESKAYA INDUSTRIYA. Therefore let us depart from this well-traveled path and look at the principal user of steel.

Aside from the construction industry, the main user of steel is the machinebuilding industry.

Let us postulate that the main way of overcoming the shortage in the machinebuilding industry is to improve steel quality. We do not have another way that is as effective as quality improvement. But then it is again necessary to turn to the metallurgists, the electric furnaces, the converters. Would you say this is more obvious to the steelmakers? No, steel quality is more obvious to machine builders. At least that is how it should be. This is how it must be. And if this is not clearly followed today, it is due to the weak alliance between these two important industries, which literally should grow into each other.

Let us take any industrially developed capitalist country. How are these industries tied together there? Very simply: most frequently the machine builders dictate their policy to the metallurgists, and the metallurgists do what is expected of them. This is where our biggest misalignment lies--

there is no real business contact between the two giants regarding the important problems of technical progress. Of course, the machine builders constantly turn to their partners, but very rarely with demands for fundamental changes in old steel production technologies and for development of new engineering materials that are capable of changing the usual approach to the manufacture of machines and equipment. Small requests predominate--for example, requests for changing the size of structural shapes or for more steel of one grade and less of another, but within the limits defined by the standards. As a result, one industry bases itself on the shortcomings of another.

Lagging behind the metallurgists has become a habit with the machine builders. Things have gone so far that when the former propose something new and progressive on their own initiative, the latter are very unwilling to accept it. Any number of such examples can be cited.

What should be the main way of improving metal quality? Categorically, it should be based on rolled sheet. The use of rolled sheet in place of castings and bar-mill products, which are being used to an increasingly smaller extent, results in a steel scrap reduction of 30-40 percent! Give the machine builders a million tons of this progressive material, and you will achieve a savings of 400 million roubles. If you ask the USSR Gossnab about the number of requests for rolled sheet, the answer is not too many. It is very regrettable that the demand for rolled sheet practically does not change, and in a number of branches, such as the Ministry for Chemical and Petroleum Machine Building, Ministry of the Machine Tool and Tool Building Industry and the Ministry of the Electrical Equipment Industry, is even decreasing. The prognosis for the future also does not inspire optimism. By the year 2000, the share of the demand for flat-rolled products by these ministries will even decrease, and it will remain practically unchanged in the Ministries of Power Machine Building, the Automotive Industry, and of Heavy and Transport Machine Building. Isn't this why the production of rolled sheet is growing at a snail's pace? Obviously, given this pace, the wasteful cast products will not relinquish their position any time soon.

In other words, the steel industry is producing rolled sheet at its own risk. Suffice it to say that from 1979 through 1983 there was a surplus of this material (on balance) in the country. The customers were not prepared to utilize it. To this day the entire machine-building industry is geared for cast products. This includes planners, designers, and producers. The machine-tool inventory of the industry is geared to castings; it continues to machine the steel. The predominance of this old technology necessitates the conversion of about 10 million tons of steel a year to shavings. On the other hand, the progressive technologies of the plastic deformation of metal (stamping, extrusion, welding, etc.) are adopted slowly, although they are the ones that are needed by the new engineering materials. If we look at the report of the Central Statistical Administration of the USSR for the 10 months of this year, we shall see that, as before, the growth of metal-cutting machine tools successfully rivals the growth of the currently more needed forge and press machines.

Let us remind ourselves of another figure: where a ton of cast products is required to produce a machine, it can be fully replaced by half a ton of the new engineering materials. The future of one of these (rolled sheet) is already clear. But the steel industry also produces other economical and effective forms of these materials: low-alloy steel, roll-formed shapes, heat-treated rolled products, and other such products. The production of these products appears to be growing, but the effect of their utilization is clearly insufficient.

For example, our country is the world's biggest producer of low-alloy steel. We are, so to speak, one hundred percent leaders in this area. But here is an interesting fact: the designers of the Combine-Building Planning-Design and Technological Institute appear to be unfamiliar with the useful properties of this steel, which makes it possible to reduce the weight of machines, and therefore have not used it. And this is not an isolated case. Many ministries that receive economical types of rolled products do not give them their due and do not use them in their designs. Instead, they use them where general-purpose steels would be quite adequate.

Roll-formed shapes appeared later than low-alloy steel, but nevertheless it took years to prove their value. This roughly was also the fate of semi-killed steel and metal powders. Vacuum-degassed steel is experiencing the same difficulties; the users show very little interest in its virtues.

As we see, science has a very substantial arsenal of developments capable of raising metal quality and reducing the weight of products. This includes materials, methods and processes. To the above one can add steel strengthened by heat treatment, controlled rolling, and microalloying of steel with niobium and vanadium. The BOF technology is clamoring more and more for attention. It is time to utilize it on the widest possible scale.

All in all, these are important reserves. By activating them we could stop chasing the "spare" tons of steel. Delay is expensive. Today's rather than tomorrow's materials are scheduled for use in the machines of the year 2000, which the designers are beginning to develop now. According to the calculations of Academician N. Fedorenko, a unit of national income in the USSR requires 1.63 times more metal products and 2.24 times more cast products than in the industrially developed capitalist countries. Such is the cost of our sluggishness.

In spite of the proclaimed intensification course, we are still slaves of the fetishism of tonnage. In the chase after "spare" tons, there is a danger of repeating the bitter experience of the last two five-year plans, during which we did not have sufficient capital investments or material and human resources for technical modernization and product quality improvement--when the spread [tirazhirovaniye] of the new technology and production processes brought forth by our science and progressive practice was unforgivably slow.

Thus we squandered a lot of what had been achieved by the Soviet school of metallurgy. Let us return for a moment to the war years and to the early post-war years, when I.F. Tevosyan was Peoples Commissar and later Minister

of Ferrous Metallurgy. With his appointment the industry finally began to fulfill the tasks mandated by the plan. But probably more important is the fact that he put the development of technology, rapid improvement of melting and teeming of steel, and development of new grades and qualities of steel at the head of the line. He did this while keeping very closely in touch with steel users. And when they confronted metallurgy with a task, he directed all efforts to accomplish it. Thus a war industry was created in a very short time, and new materials for the nuclear power industry were developed. A new industry subbranch of modern steels (alloy and high-alloy steels) was created. In this area we rapidly overtook the rival U.S. metallurgical industry, so that later the Americans had to learn from us.

Now, when we have taken the path of intensification and of rapid development of the machine-building complex, it is important to remember the traditions of our school and to develop them. We must not be simpletons who do not remember their parentage. We have been presented by the 27th Party Congress with a truly immense task of reducing nearly in half the metal content of national income. We will not accomplish this task without rapidly developing new technologies and without the use of materials.

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KINETICS OF FATIGUE FRACTURE IN STRUCTURAL STEELS OF VARIOUS GLADES IN WATER UNDER SEVERE CONDITIONS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 4, Jul-Aug 86 (manuscript received 5 Sep 85) pp 77-79

[Article by Yu.I. Babey, V.V. Zhitkov, Yu.I. Zvezdin and I.Yu. Liskevich, Physical-Mechanical Institute imeni G.V. Karpenko, UkSSR Academy of Sciences, Lvov]

[Abstract] Two very different structural steels, 15Cr3NiMoVN$_2$ low-alloy pearlitic and 05Cr13Ni6Mo2 high-strength stainless, were studied for fatigue resistance in hot water (300°C) under high pressure (15 MPa). The purpose of this study was to determine the effect of these severe conditions on the cracking rate in large plates under a symmetric low-frequency (0.005 Hz) cyclic load. For comparison, similar specimens were tested in air at room temperature and in air at 300°C. Each specimen had a notch acting as local stress concentrator. The growth of a fatigue crack was measured by the indirect electrical method not very sensitive to plastic deformation, with a resistive strain gage at the bottom of the notch recording, through a P-5827 potentiostat, the increasing width of the gap as indicator of increasing crack length. The crack propagation velocity v was calculated as function of the stress intensity coefficient ΔK according to the power-law relation $v = C(\Delta K)^n$ (C,n - empirically determined constants characterizing a material under given conditions). Curves of this relation in log-log coordinates indicate that high temperature accelerates fatigue cracking of the more corrosion-resistant 05Cr13Ni6Mo2 steel much more than fatigue cracking of the 15Cr3NiMoVN$_2$ steel, but also that the much lower cracking rate at room temperature ensures a not so high cracking rate at 300°C. The results are useful for steel selection for high-pressure vessels. References 7: 2 Russian, 5 Western.

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BEHAVIOR OF 08 ROLLED STEEL WITH VACUUM-DIFFUSION Cr-Ni COATING IN VARIOUS MEDIA

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 4, Jul-Aug 86 (manuscript received 25 Jun 85) pp 100-102

[Article by A.M. Krokhmalnyy, Yu.K. Belov and M.S. Khoma, Physical-Mechanical Institute imeni G.V. Karpenko, UkSSR Academy of Sciences, Lvov]

[Abstract] An experimental study of 08 rolled sheet steel with Cr-Ni coating was made for a determination of its electrochemical and mechanical characteristics in three corrosive media: aqueous 4% HNO_3 solution, aqueous 200 g/l superphosphate (mineral fertilizer) solution with pH= 2.8, and aqueous 200 g/l carbamide solution with pH= 9.1, at room temperature. Specimens of 1 mm thick steel sheet were given 120-130 μm thick Cr-Ni coatings with 12-20 μm grain size by vacuum diffusion of ferrochromium and Ni sublimates. The coatings were inspected for continuity by means of a reagent containing $K_4Fe(CN)_6$ and NaCl. Bare segments of the sheet surface were covered with epoxy resin for electrical insulation and with Polan varnish + 88 adhesive for comparative fatigue tests. Electrochemical measurements were made with a P-5827 potentiostat and a AgCl reference electrode, polarization curves being plotted potentiodynamically at a rate of 1 mV/s during the corrosion test over a period of one month. Mechanical tests in those media consisted of 10^5 cycles in pure symmetric flexure. Specimens were examined under a microscope before and after the corrosion-fatigue tests. The results indicate a high resistance of such a Cr-Ni coating to simultaneous pitting corrosion and mechanical fatigue in all three aggressive media, with the maximum allowable strain up to 0.20%. References: 5 Russian.

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UDC 669.1.017+620.17:669.14.018.25

SOME STRUCTURAL ASPECTS OF CRACK PROPAGATION IN HEAT-RESISTANT STEELS UNDER CYCLIC THERMAL AND MECHANICAL LOAD

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 30 May 84) pp 13-17

[Article by S.I. Tishayev, G.A. Kotelnikov, R. G. Miftakhov and T.V. Tetyuyeva, Kuybyshev Polytechnic Institute, Kuybyshev, and Ukrainian Scientific Research Institute of Special Steels, Zaporozhye]

[Abstract] Two punch steels, 4Cr4WMoVSi (DI22) and 4Cr3WVMoSi (DI71), were tested for a study of crack propagation kinetics and irreversible structural changes under conditions of thermomechanical fatigue. Tests were performed on 2 mm thick strips 12 mm wide and 80 mm long, with a 0.1 mm deep stress concentrating 60° V-notch on one surface. These strips had been cut from

commercial plates 180x180 mm^2 large, then quenched from 1060°C (DI22) or 1130°C (DI71) in oil, and tempered at 620°C (DI22) or 650°C (DI71) for 2 h so as to ensure a tensile strength of 1700-1800 MPa. For the test, one batch of each steel was heated to 1000±40°C at the stress concentrator and one batch was heated to 850±30°C at the stress concentrator. Both batches were then cooled to 550±30°C and heated again in cycles of 2 s duration. They were simultaneously loaded mechanically to a stress cycle amplitude of ±625 MPa at the concentrator tip and subsequently the crack tip. After 50 or 100 cycles, the strips were cooled to room temperature for measurement of the microhardness with a PMT-3 tester under a 0.98 N load, measurement of the crack depth under the stress concentrator and determination of the crack propagation rate, and measurement of the widening of the (211) line along the vertical section of a strip in an RKD x-ray diffractometer camera with CrK_{α} - radiation source. Microstructural and fratographical examination were done by optical and electron microscopy. The results reveal that in both steels the crack propagation kinetics and the fracture mode under conditions of thermo-mechanical fatigue correspond to irreversible structural changes within the thermal influence zone. Quenching and high-temperature tempering were found to lower the cracking rate and raise the structural stability more than does lowering the temperature gradient during temperature cycling by modification of the alloy content or of the geometrical design. References 10: 9 Russian, 1 Western.

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UDC 620.181.41:669.14.018.298

DIAGRAM OF ISOTHERMAL TRANSFORMATION OF RESIDUAL AUSTENITE DURING TEMPERING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 2-5

[Article by B.B. Vinokur, M.V. Belous, S.Ye. Kondratyuk and L.A. Semenova, Casting Problems Institute, UkSSR Academy of Sciences]

[Abstract] Breakup of residual austenite in the carburized layer of 18CrMnNiMoV cast steel during tempering was studied on a model steel with the same composition except for a much higher carbon content so as to ensure a more uniform carbon distribution over the thickness of that layer and thus simultaneous transformation throughout its volume. Specimens of 95CrMnNiMoV cast steel (0.95% C, 1.43% Mn, 1.35% Cr, 0.90% Ni, 0.24% Mo, 0.11% V, 0.40% Si) were quenched from the standard carburization temperature of 880°C, after they had been soaked at that temperature for 60 min in synthetic slag to prevent their oxidation and decarburization. The transformation of residual austenite during subsequent tempering was tracked by the method of differential thermomagnetic analysis. The results of heating at a constant rate in a magnetometer furnace reveal precipitation of ε-carbide from the supersaturated α-phase below 200°C, breakup of residual austenite at 200-570°C, accompanied by transformation of ε-carbide into paramagnetic cementite at 390-500°C, and incomplete breakup of residual austenite above 570°C. Breakup of residual austenite takes also place during cooling from 570°C down, with transformation

into martensite occurring below 165°C. Isothermal tempering at various temperatures covering the 225-570°C range revealed shorter breakup incubation periods as well as shorter 50%-breakup time and 100%-breakup time at higher temperatures. This indicates the expediency of intermediate high-temperature tempering of 15CrMnNiMoV cast steel.

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STRUCTURE DEPENDENCE OF TECHNOLOGICAL PLASTICITY CHARACTERISTICS OF COLD-ROLLED LOW-ALLOY HIGH-STRENGTH STEELS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 5-8

[Article by N.M. Fonshteyn, L.G. Skorokhodova, O.N. Yakubovskiy and Ye.V. Afanasyev]

[Abstract] Two new ferritic-martensitic high-strength automotive sheet steels, 03CrMnAl low-alloy steel and 0.8MnSiAlTi microalloy steel, are evaluated from the standpoint of formability of cold rolling and in punching for replacement of the not sufficiently plastic 08 rimmed plain carbon steel and the not as strong 09Mn2 alloy steel. Serving as indicators of technological plasticity are the strain hardening exponent n and the index of normal plastic-strain anisotropy r, along with the ratio of 0.2% yield strength to ultimate strength and the product of ultimate strength and percentage uniform elongation. Experimental studies and regression analysis of the data have established the quantitative dependence of these parameters on structural factors such as ferrite grain size and percentage reduction as well as sulfur content. The results indicate that optimum combination of strength and plasticity is achievable by comminution of the ferrite grains and minimizing the amount of elongated nonmetallic inclusions. The 03CrMnAl steel, containing only 10-15% martensite, is found to be most suitable. References 9: 7 Russian, 2 Western.

2415/9716
CSO: 1842/25

UDC 621.785.533:621.762.5

HIGH-TEMPERATURE CARBONITRIDING OF SINTERED HIGH-DENSITY POWDER STEELS

Moscow METALLOVEDENIYA I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 8-11

[Article by J. Baran, Bialystok Polytechnical Institute (Poland) and Ye. L. Gyulikhandanov, Leningrad Polytechnical Institute]

[Abstract] Powders for production of sintered steels in Poland are now compacted to up to 99% theoretical density by the rotational method. A study of

high-temperature carbonitriding of such high-density powder steels was made in experiment with ASC100.29 Fe powder alone or mixed with Distalloy AE powder (94% Fe+ 4% Ni+ 1.5% Cu+ 0.5% Mo) in various ratios, graphite having been added in each case in an amount necessary for producing a steel with 0.18% bound carbon. Sintering at 1120°C for 1 h was followed by rotational compaction under a nominal pressure of 400-450 MPa until a material with density of 7.58-7.68 g/cm^3 had been obtained. Specimens of these steels were carbonitrided at 850°C for 1 h in a controllable atmosphere of producer gas, controllable by variation of the amounts of $CH_3COOC_2H_5$ and NH_3 added to CH_3OH. After this treatment the specimens were quenched and then tempered at 175°C for 1 h. The results of hardness measurements, confirmed by measurements of C and N_2 distributions in the diffusion layer, indicate that carbonitrided steels are much more hardenable and especially so steel made by unalloyed Fe powder than pseudocarbonitrided ones or steels plainly annealed without carbonitriding. The surface hardness of all these steels becomes very high, up to Vickers number 1100, after carbonitriding with C+ N_2= 1.2% (plain steel) or C+ N_2= 1.0% (alloy steel) and quenching in aqueous solution of WODOL-3 polymer. Specimens of these steels were also tested for tensile strength, bend strength, and impact strength, porosity tests having revealed a volume fraction of micropores not larger than 2% in all these powder steels regardless of composition. Experimental KPP bushings made of these steels for the Fiat 126p small automobile were found to have retained the mechanical characteristics of the blank material. Sintered steel bushings will now be put in small automobiles at the Bielske-Biała Automobile Manufacturing Plant. References 3: 2 Russian, 1 Polish.

2415/9716
CSO: 1842/25

UDC 621.78:535.211

DEPENDENCE OF STRUCTURE AND PROPERTIES OF HIGH-SPEED TOOL STEELS ON MODE OF LASER-PULSE TREATMENT

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 11-14

[Article by V.S. Dyachenko, Kharkov Aviation Institute]

[Abstract] The problem of hardening high-speed tool steels by laser-pulse treatment is examined on the basis of experimental data and their metallographic phase-structural analysis. Quenched specimens of five such steels (R-9Co5, R-9Mo4Co8V, R-10Co5V5, R-12V5Mo, R-12V2Co8Mo3) were treated with an LTU-2M laser in air. The duration of laser pulses was varied over the 1.5-8.0 ms range and the laser energy density at the steel surface was varied by shifting that surface relative to the focal plane of the laser objective. The microhardness is found to depend on the amount of residual austenite and on the number of secondary carbides, both determined by the temperature before second quenching, as well as on the duration of laser pulses. A close correlation between these influencing factors allows concluding that the maximum hardness of these steels will be attained by second quenching from

a temperature at or near the solidus point with laser pulses of 3 ms duration. Such a treatment with an energy density of 120 J/cm^2 produces a martensite-carbide structure almost completely free of residual austenite, while pulses of longer duration and with correspondingly more energy cause sweating of the steel and have a weaker hardening effect. References: 5 Russian.

2415/9716
CSO: 1842/25

UDC 669.187.28

SMELTING HIGH-VANADIUM ELECTRIC-FURNACE IRON FROM VANADIUM METAL RESIDUUM

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 12 Oct 84) pp 18-21

[Article by Yu. A. Deryabin, Yu.S. Shchekalev, L.A. Smirnov, V.D. Naryzhnyy and Ya. I. Ostrovskiy, Ural Research Institute of Ferrous Metals, Sverdlovsk]

[Abstract] Experiments were conducted on the process of smelting vanadium iron from vanadium metal residuum. During each test, a charge weighing between two and three tons was melted in an OKB-955 electric direct-reduction furnace. For each charge, the specific consumption of coke and lime per one ton of residuum was: 100 to 160 kg of coke, with an average of 120 kg, and 27 to 100 kg of lime, with an average of 70 kg. The specific consumption of electricity was 950 to 1500 kwh, with an average of 1300 kwh. The bath was held for 20 to 40 minutes before being tapped into the ingot molds, at which time the temperature was measured with an optical pyrometer and samples taken for chemical analysis. The temperature during tapping ranged from 1350 to 1520°C, with an average of 1450°C. The concentration of Fe in the final slag was reduced to a minimum average of 1.7%, which corresponded to the following chemical composition for the iron: 2.8% carbon, 3.8% vanadium, 2.1% chrome, 0.5% silicon, 0.7% manganese, 0.3% titanium, 0.05% sulfur, and 0.06% phosphorus. Reducing the Fe concentration hardly affected the concentration of carbon, silicon, and manganese in the iron, but did lead to a noticeable increase in the concentration of vanadium and chrome. A higher carbon concentration also resulted in higher concentrations of vanadium and chrome. When the average concentration of iron oxide in the final slag was below 4%, the coefficient for the distribution of vanadium between the slag and the iron reached 0.35 to 0.38, which is about double the coefficient obtained during conventional smelting. The degree of vanadium absorption by the iron exceeded 90% using the experimental method. The results of the tests show that high-vanadium iron can be smelted from vanadium metal residuum using this direct-reduction method. References 7: 5 Russian, 2 Western (in Russian translation).

13050/9716
CSO: 1842/37

UDC 669.15'292'295'781--194:620.1

OPTIMIZING THE MECHANICAL PROPERTIES OF 10KhSND STEEL MICROALLOYED WITH TITANIUM, VANADIUM, AND BORON

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 19 Dec 85) pp 91-92

[Article by V. A. Kharchenko, Ye. F. Dolzhenkova, N. A. Manyak and I.V. Machikina, Donetsk Polytechnical Institute]

[Abstract] The optimal concentration of microalloying elements needed to obtain enhanced mechanical properties in 10KhSND steel were determined. The mechanical properties subject to optimization were: tensile strength, yield point, percentage elongation, percentage reduction in area, impact strength, and fracture energy. The mechanical tests were performed on transverse tensile-test and impact-test specimens made from strip 12 mm thick. The Harrington desirability function was used to reconcile the results of the mechanical tests with the quantities of microalloying elements added to the steel. The most favorable combination of alloying elements found was 0.015% titanium, 0.060% vanadium, and 0.003% boron. References: 3 Russian.

13050/9716
CSO: 1842/37

UDC 539.432:620.178.2.620.178.38:620.186.4:621.438:620.184.6

GROWTH OF FATIGUE CRACKS IN NICKEL ALLOYS AT HIGH TEMPERATURES

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 9 Oct 85) pp 3-7

[Article by V.T. Troshchenko, A.Ya. Krasovskiy, V.N. Yezhov, I.V. Kramarenko, A.V. Prokopenko, and I.A. Makovetskaya, Strength Problems Institute, UkSSR Academy of Sciences, Kiev]

[Abstract] Two heat-resistant nickel alloys for gas-turbine blades, polycrystalline ZhS6KP and grain-oriented ZhS6FNK with not very different chemical compositions, were tested for high-temperature fatigue resistance. Specimens with an active cross-section area of 5x10 mm^2 were loaded in pure flexure, symmetrically with respect to the principal axis corresponding to maximum stiffness, at a frequency of 400 Hz. Tests were performed at two high temperatures, 1073 K and 1273 K, as well as at room temperature (293 K). The crack length was measured under a microscope with synchronous optical strobing. The stress intensity coefficient was calculated according to the standard formula for a specimen with lateral crack under pure flexure. Microstructural surface examination was done by the Laue method. The results indicate a lower threshold stress intensity coefficient and a higher crack growth rate at high temperatures. They also indicate that ZhS6FNK steel is at all three temperatures much more fatigue-resistant and at the high temperatures much more oxidation-resistant than ZhS6KP steel. Fracture of both steels was found to change from brittle to ductile at higher temperatures or under a lighter load. References 9: 5 Russian, 4 Western.

2415/9716
CSO: 1842/35

UDC 620.172.254:620.182:546.821

STRAIN-RATE DEPENDENCE OF RESISTANCE OF WTi16 TITANIUM ALLOY TO PLASTIC DEFORMATION

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 26 Mar 85) pp 45-48

[Article by N.N. Popov, A.G. Ivanov and S.A. Morozov, Moscow]

[Abstract] A study of the ($\alpha + \beta$)-phase WTi16 titanium alloy for fasteners was made, the purpose being to determine the dependence of its mechanical and microstructural characteristics, including resistance to plastic deformation, on the strain rate. Specimens of this alloy were produced from a rod 14 mm in diameter, turned down to a 3.2 mm diameter over an 8 mm long gage segment. They were heat treated by annealing at a temperature of 1053±10 K for 1-2 h with subsequent cooling first in a furance to 773 K at a rate of 274-276 K/min and then in air + heating to and holding for 2 h at 1083±10 K with subsequent quenching in water + aging at temperature of 813-853 K for 6-10 h with subsequent air cooling. These specimens were tested so as to approach, as nearly as possible, constant rates of plastic deformation. Short static tests were performed in an R-5 tensile machine with the strain rate varied over the 10^{-3}-10^{-1} s^{-1} range. Dynamic tests at an approximately 500 s^{-1} strain rate were performed in a vertical impact machine with drop hammer. These tests were followed by microhardness measurement with a PMT-3 tester and microstructural examination under a "Neophot-2" optical microscope over both the fracture zone and the not plastically deformed head. Statistical analysis of the data and theoretical analysis, taking into account the elastic component of deformation energy and strain, have yielded stress-strain curves and energy characteristics corresponding to various strain rates as well as the variances of strength and energy characteristics. An increase of the rate of plastic deformation was found to raise the yield strength and the ultimate strength of this alloy, but also to decrease its energy absorption capacity and thus to promote its brittle fracture. References: 8 Russian.

2415/9716
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UDC 669.27:620.18

DISTRIBUTION OF RHENIUM IN POWDER-METALLURGICAL TUNGSTEN ALLOYS

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 3 Oct 85) pp 134-138

[Article by K.B. Povarova, Ye.K. Zavarzina, P.V. Makarov, A.B. Olshanskiy, and V.I. Gachetov, Moscow]

[Abstract] An experimental study was made concerning the powder metallurgy of tungsten with substitutional alloying elements for the purpose of optimizing the distribution of that element to a most nearly uniform one.

Five methods of mixing and subsequent sintering were tested, for comparative evaluation, on binary alloys of W with up to 10 wt.% Re. Powders of both metals with 3-10 μm mean grain size were: 1) mechanically mixed for 2 h in a tumbling barrel and then sintered at 2100°C in hydrogen; 2) additionally homogenized at 2500°C for 5 h and at 2700°C for 1 h in an electrical resistance furnace (uniform heating of specimens); or 3) additionally heated to 2600°C for 1.5 h by ion bombardment under a vacuum of $(1-2)\cdot10^{-5}$ torr (intense heating of surface layer); 4) mechanically mixed in a vibratory abrader for 3-4 min at an operating frequency of 16.7 Hz and then sintered at 2100°C in hydrogen; 5) mechanically mixed in a high-energy ball mill (mass of balls and mass of powder in 7:1 ratio) for 0.3-60 h with an impeller speed of 170 rpm and then sintered at 2100°C in hydrogen. Alloys with up to 5 wt.% Re were also produced by mechanically mixing W powder with 50% W + 50% Re composite powder (Re having been deposited on W powder upon reduction of NH_4ReO_4 at 550°C), either in a tumbling barrel for 2 h or in a vibratory ball mill (balls-to-powder mass ration varied from 7:1 to 4:1) at an operating frequency of 16.7-25 Hz, and then sintering at 1800°C for 2 h under a vacuum of 10^{-4} torr. The results of microstructural examination of the products under a "Neophot-2" optical microscope and of x-ray spectral microanalyis using JSM-U3 and "Cameca-46MS" instruments indicate that the most nearly uniform distribution of Re in W-Re powder alloys is attended by mixing in a vibrator abrader or in a high-energy ball mill. References 6: 5 Russian, 1 Western.

2415/9716
CSO: 1842/39

UDC 669.04:621.039.61

INTERACTION OF FINE-DISPERSE TUNGSTEN AND MOLYBDENUM POWDERS WITH GASES

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 5 Aug 85) pp 139-142

[Article by R.U. Kalamazov, V.V. Khaydarov and Yu.V. Tsvetkov, Chirchik and Moscow]

[Abstract] Desorption of gases O_2, H_2, N_2, CO, CO_2 and H_2O vapor from the surface of fine-disperse (5-15 m^2/g) tungsten and molybdenum powders was measured at temperatures covering overall the 20-900°C range, H_2 and O_2 as well as H_2O having been absorbed during reduction of WO_3, MoO_3 and during cooling of the metal, then adsorbed by the metal powder during storage in air. Measurements were made with a liquid-nitrogen trap for freezing the gases out or without freezing them out. The desorption volume at room temperature was found to be much larger with than without freezing. With freezing at -196°C, the desorption volume approximately the same from both powders was found to first increase with rising temperature and then remain almost constant above 400°C. Without freezing, desorption was found to begin above 450°C (W) or 100°C (Mo) and to increase rapidly with rising temperature. Differential thermograms and x-ray phase analysis revealed concurrent oxidation ($W \rightarrow WO_2 \rightarrow WO_{2.72} \rightarrow WO_3$, $Mo \rightarrow Mo_2O_3 \rightarrow MoO_2 \rightarrow MoO_3$) and also desorption of bound oxygen, oxygen having combined with carbon (CO, CO_2) which had penetrated the powder

during passivation with benzene vapor and then resurfaced during annealing. References 8: 6 Russian, 2 Western (both in Russian translation).

2415/9716
CSO: 1842/39

UDC 669.296.018.8:621.039.5

EFFECT OF ALLOYING OF AMORPHIZATION AND PROPERTIES OF Zr-Cu ALLOYS

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 8 Jan 86) pp 143-146

[Article by I.A. Tregubov, L.N. Yevseyeva and S. B. Maslenkov, Moscow]

[Abstract] An experimental study of the eutectic Zr+ 26.1 atoms.% Cu was made for the purpose of determining the effect of Ni, Nb, Mo, Sn additions on its amorphizability and mechanical properties in the amorphous state. The alloy and six modifications (Zr+ 29.2 Cu+ 1.4 Sn, Zr+ 29.2 Cu+ 0.8 Nb, Zr+ 29.2 Cu+ 2.3 Nb, Zr+ 29.2 Cu+ 1.6 Mo, Zr+ 16.2 Cu+ 17.1 Ni, Zr+ 17.9 Cu+ 15.4 Ni) were quenched from liquid to amorphous solid state on a copper disk rotating at a speed of 2700 rpm. Very long 0.03 mm thick and 5 mm wide ribbons produced by this method were examined by the x-ray diffraction method and were tested mechanically for microhardness, tensile strength, and plasticity in flexure. The results indicate that addition of a third element with an atomic radius appreciably unequal to that of Zr improves the already excellent amorphizability of the Zr-Cu alloy as well as its mechanical properties and thermal stability. Fractograms of amorphous ribbons revealed splitting into halves along the shear zone under uniaxial tension at room temperature. The amorphous state was found to be unstable, with transition to a crystalline state occurring at a temperature dependent on the additional element and its concentration. References 4: all Western.

2415/9716
CSO: 1842/39

UDC 539.67

INTERNAL GRAIN-BOUNDARY FRICTION IN UNALLOYED COPPER AFTER IRRADIATION BY CONTINUOUS-WAVE LASER

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 29 Jan 85) pp 147-150

[Article by G.M. Ashmarin, V.V. Aulin, M.Yu. Golubev and S.D. Zvonkov, Moscow]

[Abstract] Treatment of unalloyed (99.99%) copper with a scanning continuous laser beam was studied for the purpose of determining the effect of such a treatment on relaxation of grain boundaries and internal friction. The experiment was performed on 78 mm long and 0.75 mm in diameter copper wires after they had been annealed at a temperature of 1030 K for 2 h in an argon

atmosphere. They were treated with a 200 W continuous-wave CO_2-laser, a wire being passed 1-100 times lengthwise through the laser spot 1-2 mm in diameter at a velocity of 19-25 mm/s. They were afterwards tested for the temperature dependence of the damping decrement and of internal friction over the 300-1200 K temperature range, in 10 K steps and at a heating rate about 2°C/min respectively, under a vacuum of 10^{-2} Pa in a RU-1 machine with an inverted torsional pendulum oscillating at a frequency of 1 Hz. In a control experiment identical copper wires were heat-treated in a furnace at a temperature of 1300 K for 5 min, this length of time corresponding to the maximum duration of laser treatment. The data have been evaluated by the Nowick-Berry method, yielding the relaxation activation energy from the temperature of the maximum grain-boundary peak according to the Wert-Marx relation as well as the parameter Δ characterizing the degree of peak relaxation and the parameter β characterizing the width of the relaxation time spectrum. The results indicate that irradiation by a continuous-wave laser accelerates and even anomalizes self-diffusion of relatively cold copper. Supplementary isothermal annealing at 1030 K for 1 h was found to stabilize the microstructure by more thorough recrystallization of the surface layers. References 4: 2 Russian, 2 Western.

2415/9716
CSO: 1842/39

UDC 666.76.01

EFFECT OF OXIDATION ON STRENGTH AND THERMAL STABILITY OF MATERIAL BASED ON Si_3N_4

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 86 (manuscript received 14 Aug 84) pp 67-70

[Article by V.A. Lavrenko, A.A. Chernovolenko, S.I. Sopenko, V.I. Zubov, A.F. Alekseyev, Yu.G. Gogotsi, A.B. Goncharuk and V.V. Shvayko, Kiev Polytechnical Institute and Strength Problems Institute, UkSSR Academy of Sciences, Kiev]

[Abstract] In a study of ceramics based on the Si_3N_4-SiC system, the NKKKM-83a material (70% Si_3N_4 + 30% SiC) was tested for the effect of high-temperature oxidation its strength and thermal stability. These materials are produced by reaction-sintering, 2 wt.% MgO having been added as activator in this case. Specimens 2.3x5x25 mm^3 in size were heated in a tube furnace to temperatures ranging from 800°C to 1500°C at a rate of approximately 5°C/s, held at each temperature for 3 h in an oxidizing atmosphere, and then quenched in air to room temperature. They were then tested mechanically in flexure under a concentrated loading force in an MIK-9 machine. The results indicate that oxidation at temperatures up to 1200°C lowers the strength at room temperature but not the strength of 1200°C, oxidation at higher temperatures up to 1300°C raises the strength at both room temperature and high temperature, and oxidation at 1400°C or higher temperature lowers the strength. Similar specimens 2.3x5.8x54 mm^3 in size were tested in flexure, after oxidation at 1350°C for 3 h, in a TsD-4 machine with an argon atmosphere precluding further oxidation during the test. This test established the temperature dependence of the strength of oxidized material and revealed a peaking of the strength to a maximum at 1000°C in this particular case. Such a response of the NKKK-83a material to high-temperature oxidation is different than that of the previously studied NKKK-79 material with a different Si_3N_4:SiC ratio. An explanation has been found in the oxidation kinetics. Phase analysis in a DRON-2.0 x-ray diffractometer with CuK_α-radiation source revealed preferential oxidation of the Si_3N_4 component. Heat resistance curves plotted on the basis of the data and representing the dependence of residual strength on the temperature drop, such as during quenching, indicate the critical temperature drop for unoxidized material and for material oxidized at various high temperatures, a larger than critical

temperature drop causing the residual strength to drop. Oxidation at temperatures of 1300-1350°C evidently increases the critical temperature drop to 425°C from 400°C for unoxidized material. References 11: 5 Russian, 6 Western.

2415/9716
CSO: 1842/35

UDC 666.266.7:621.372.8

ANISOTROPY OF LIGHT ABSORPTION BY COLOR CENTERS IN WAVEGUIDES PRODUCED ON PHOTOCHROMIC GLASSES BY DIFFUSION

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 21 Nov 84) pp 549-554

[Article by L.B. Glebov, N.V. Nikonorov, G.T. Petrovskiy and V.A. Tsekhomskiy]

[Abstract] The anisotropy of light absorption by color centers in waveguides on photochromic glasses is analyzed for an explanation of its cause. First considered is birefringence in photochromic glasses, an experimental study having been made with FKhS-4 silver halide and FKhS-7 copper halide glasses. Waveguides on these glasses were produced by low-temperature (430°C) ion-exchange diffusion in a KNO_3 melt for durations of 0.25-6 h, whereupon the refractive indexes at the 0.63 μm wavelength were determined from measurement of the resonance-excitation angle with a set of prisms. Absorption of TE modes and TM modes is considered next, an experiment having been performed with light from a He-Ne laser (wavelength λ=0.63 μm) circularly polarized for prevention of possible parasitic photoinduced dischroism. Coloration and relaxation kinetics were also examined, upon application of an intense activating light beam for a duration of 5 min, the density of induced absorption having then been recorded with a probing light beam. Further special experiments have revealed that absorption anisotropy in the form of dichroism is caused neither by the specific waveguide geometry nor by orthogonality of activating and probing light beams, nor by preferential orientation of photosensitive microcrystals, but only by the photoelasticity effect under compressive stresses in the surface layer with a linear relation between the magnitudes of birefringence and dichroism. Color centers in photochromic glasses are evidently anisotropic. The density of induced absorption was found to increase with higher order of TE or TM mode, no absorption of zeroth-order modes TE_0 and TM_0 modes having been found to occur in a waveguide on FKhS-7 copper halide glass. Copper, added to all industrial photochromic glasses, evidently influences their photosensitivity, with Cu^+ ions participating in the ion exchange so that the Cu concentration in the surface layer decreases. This lowers the photosensitivity to lower-order modes propagating through that layer. The authors thank V.Ya. Alayev for determining the Cu concentration in the surface layers of the two glasses and M.V. Babukov for producing planar waveguides on these glasses. References 13: 10 Russian, 3 Western (2 in Russian translation).

2415/9716
CSO: 1842/38

UDC 535.8.666.189.2:666.11:621.039.533

DEPENDENCE OF FORMATION OF RADIATIVE COLOR CENTERS IN OPTICAL GLASS FIBERS ON TECHNOLOGICAL FACTORS

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 21 Nov 84) pp 555-561

[Article by Ye. M. Dianov, V.N. Karpechev, N.S. Karpychev, L.S. Korniyenko, S.M. Mazavin, S.I. Miroshnichenko, A.O. Rybaltovskiy and P.V. Chernov, General Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] Formation of radiative color centers absorbing visible and near-infrared radiation in optical glass fibers was studied experimentally for the purpose of determining the dependence of their formation, as well as of their thermal and optical stability, on the fiber technology and particularly on the mode of core extrusion. Fibers of pure quartz glass, with reflective sheath of borosilicate glass, were produced for this study by four methods: fibers A by the MCVD method of chemical deposition from the gaseous phase on the inside surface of a support tube or by the "rod and tube" method; fibers B by the VAD method of axial deposition from the gaseous phase; fibers C from KU-1 synthetic quartz glass; fibers D by deposition on the lateral surface of a cylindrical substrate upon hydrolysis of $SiCl_4$ in the flame of an oxyhydrogen torch and subsequent drying in $SOCl_2$. The sheath was for all fibers produced by the MCVD method. All fibers of each group were drawn from the same ingot, either with an oxyhydrogen torch or with a graphite heater. Fiber specimens 4-10 m long were bombarded with 10^3-10^5 rad doses of 1.2 MeV γ-quanta from a Co^{60} source, at a rate of approximately 10^3 rad/s, at temperatures of 77 K and 300 K (with nitrogen cooling). Absorption spectra over the 0.3-1.9 μm range of wavelengths were recorded at 120 points along a fiber with a 2-beam 2-monochromator instrument and an Elektronika D3-28 minicomputer for automatic data processing. Absorption induced by ionizing radiation was recorded after fibers had been annealed at temperatures up to 600 K and then cooled to 77 K. The absorption spectra were recorded following exposure to γ-radiation and then, after bleaching by radiation from a He-Ne laser (wavelength λ = 0.633 μm) for 20 min, following exposure to radiation from a N_2-laser (wavelength λ = 0.337 μm), then again after bleaching for 10 min to separate absorption by radiative color centers generated by N_2-laser radiation and annihilated by He-Ne laser radiation from absorption by radiative centers generated or annihilated by N_2-laser radiation and not annihilated by He-Ne laser radiation. The results indicate that optical glass fibers produced by the VAD method have the highest radiation-optical stability, while those produced by the MCVD method feature stronger induced absorption of infrared radiation and more intense 0.67 μm, 0.55 μm, 0.38 μm absorption bands. Only in the spectra of fibers with a high OH-group concentration and of those dried in $SOCl_2$ (group D) was there found an 0.8 μm induced-absorption band. References 12: 10 Russian, 2 Western.

2415/9716
CSO: 1842/38

UDC 621.315.592

EFFECT OF ADSORPTION ON ENERGY SPECTRUM OF SURFACE OF CHALCOGENIDE GLASSES ACCORDING TO DATA BASED ON PHOTOLUMINESCENCE AND PHOTOELECTRICAL MEASUREMENTS

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 3 Dec 84) pp 562-567

[Article by V.V. Milov, T.N. Mamontova, A.S. Kochemirovskiy and L.V. Pivovarova, Physics Institute, USSR Academy of Sciences, Dagestan branch, Makhachkala, Kharkov Construction Engineering Institute, and Kharkov Polytechnical Institute imeni V.I.Lenin]

[Abstract] A study of the surface of chalcogenide glasses adsorbing water vapor was made by measurement of photoconduction, photoluminescence, and the external photoelectric effect. All these measurements were made on two isomorphous glasses with chain structure, As_2S_3 and As_2Se_3; photoluminescence only was measured in the case of structurally rigid Ge_2S_3 glass. Those two glasses had been founded under vacuum at a temperature of 700°C by continuous stirring for 10 h and subsequent cooling in a turned-off furnace and then either annealed at 200°C or quenched from 600°C. The third glass had been founded by an analogous process, but with a highest temperature of 960-1000°C and continuous stirring of the melt for 40-50 h. The experimental results and an analysis based on the energy band structure, the Mott-Street theory of D-centers, and the current-voltage characteristics of electron photoemission reveal a donor effect of adsorbed water vapor. This effect is indicated by positive charging of the glass surface with attendant electron enhancement and a swelling of the subsurface region in the case of As_2S_3 and As_2Se_3 glasses, the more rigid Ge_2S_3 glass being less likely and therefore not so radically restructured. References 16: 11 Russian, 5 Western (2 in Russian translation).

2415/9716
CSO: 1842/38

UDC 539.2:621.316.8

INTERACTION OF FUSIBLE GLASS AND CrB_2 REFRACTORY

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 30 Oct 84) pp 574-578

[Article by L.T. Akulova, M.V. Vlasova and N.G. Kakazey, Institute of Materials Science Problems, UkSSR Academy of Sciences, Kiev]

[Abstract] A study was made concerning the interaction of a fusible glass and a refractory, this factor being generally disregarded in investigations of thick-film electrical resistors although some interaction occur even during low-temperature heat treatment. Two glasses were selected for the study, glass D= 55 wt.% PbO + 25 wt.% ZnO + 12 wt.% B_2O_3 + 8 wt.% SiO_2 and glass B= 47 wt.% PbO + 20.5 wt.% ZnO + 14 wt.% B_2O_3 + 12 wt.% MnO_2 + 6.5 wt.% SiO_2, with CrB_2 selected as the refractory component in each case. Each glass and

the refractory as well as the composites were heat treated in air according to the thick-film technology: glass B at 373-1073 K, CrB_2 at 373-1173 K, and glass B + CrB_2 at 373-1173 K. Interaction products in glass B were determined on the basis of EPR spectra, namely waveform and amplitude of EPR signals measured at temperatures from 77 K to 500 K. Interaction products in glass D were determined on the basis of ESR spectra, interaction in each case having been found to occur at temperatures above the glass softening point. The spectra in each case indicate diffusion of Cr^{3+} and B^{3+} ions into the glass, in glass B also Mn^{2+} ions as well as a $Mn^{3+} \rightarrow Mn^{2+}$ transition, and an oxide phase $(Cr_2O_3)_n \cdot (B_2O_3)_m$ forming as inclusion in CrB_2 at temperatures from 823 K up. Interpretation and quantitative analysis of the results from the standpoint of diffusion process explain the mechanism and the kinetics of glass-CrB_2 interaction. References 6: 4 Russian, 2 Western.

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CSO: 1842/38

UDC 666.1.12.4:666.161

GLASSES OF $PbGeO_3$-PbF_2-Al_2O_3 SYSTEM

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 24 Jan 85) pp 579-582

[Article by N.M. Arutyunyan, R.M. Oganesyan, and V.D. Khalilev, General and Inorganic Chemistry Institute, ArSSR Academy of Sciences, Yerevan]

[Abstract] An experimental study of $PbGeO_3$-PbF_2-Al_2O_3 glasses was made for the purpose of determining the effect of PbF_2 on the $PbGeO_3$ matrix. The glasses were founded in platinum crucibles at temperatures of 850-1100°C for 30 min, after $PbGeO_3$ glass hasd been synthesized from extra-pure Pb_3O_4 and GeO_2 at 1100°C for 1 h and crushed to a specific surface area of 1300 cm^2/g with subsequent addition of extra-pure PbF_2 and Al_2O_3. Vitrification was examined after 10-15 g samples of melt had been poured on a cold metal plate. The liquidus temperature was determined, within ±10°C, by means of an OD-102 derivatograph. Thermal expansion was measured wtih a DKV-4A dilatometer during heating at a rate of approximtely 3°C/min. Infrared absorption spectra covering the 400-1500 cm^{-1} range were scanned at a rate of 64 cm^{-1}/min and recorded in a UR-20 spectrophotometer, 5 mg samples of glass powder having been for this purpose molded in 700 mg KBr. Products of glass crystallization were determined on the basis of diffractograms in a DRON-1.5 x-ray diffractometer with CuK_α-radiation source and Ni filter. The data were used to plot the constitution diagram of the ternary system, indicating the range of glass transition, and the liquidus lines for the pseudo-binary systems $PbGeO_3$-(0-70 mol.% PbF_2) and $PbGeO_3$-(0-30 mol.% Al_2O_3) as well as for the ternary system with a fixed 10 mol.% Al_2O_3 content. The results indicate that PbF_2 lowers the liquidus temperature and widens the glass transition range, while together with AlF_2 forming a lattice structure. The linear thermal expansion coefficient increases linearly and the glass transition temperature drops less than linearly with increasing PbF_2 content. References 10: 7 Russian, 3 Western (1 in Russian translation).

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UDC 666.112.8

DEPENDENCE OF LEACHING RATE IN PLATES OF PHASE-SEGREGATED SODIUM-BORON SILICATE GLASSES ON ACID CONCENTRATION

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 29 Jan 85) pp 583-590

[Article by T.V. Antropova and G.P. Roskova, Silicate Chemistry Institute imeni I.V. Grebenshchikov, USSR Academy of Sciences, Leningrad]

[Abstract] An experimental study of acid leaching of 8/70 sodium-boron silicate glass (synthesis 8 Na_2O + 22 B_2O_3 + 70 SiO_2 — analysis 6.8 Na_2O + 20.9 B_2O_3 + 0.3 Al_2O_3 + 72.0 SiO_2, fractions in mol.%) was made for the purpose of determining the dependence of the leaching rate on the acid (HCl, H_2SO_4, HNO_3) concentration and on the temperature. Prior to leaching, 4 mm thick and 20x20 mm^2 large plates were heat treated so as to ensure attainment of phase equilibrium in glass with interpenetrating segregated phases. Plates of $8/70_k$ glass were quenched in air from a temperature about 800°C and then soaked either at 550°C for 190 h or at 700°C for 5 h. Plates of $8/70_a$ glass were soaked at 550°C for 144 h. Ground down to 2 mm thickness, the plates were variously leached without stirring: plates of $8/70_k$ glass in HCl (0.3 N, 1.2 N) or in HNO_3 (0.3 N, 1.2 N) at 20°C, 50°C, 70°C, or in H_2SO_4 (1 N, 3 N) at 20°C, plates of $8/70_a$ glass in 0.1 N HNO_3 or 3 N HCl at 50°C, or in (0.1-3) g-eq./l HCl at 100°C. In all tests the ratio of leachant volume to glass volume was 250:1 so as to ensure a constant pH throughout the entire leaching process. The porous layer and the kinetics of its buildup were monitored under an MIN-8 microscope. The porous structure of leaching products was quantitatively analyzed by the adsorption method, radii and volume of pores being determined from the 18°C isotherms of water vapor adsorption and desorption. The results indicate that the rate of porous layer buildup is lower in glass heat treated at a higher temperature, that increasing the HCl or HNO_3 concentration from 0.1 to 1 g-eq./l increases the leaching rate at 50°C and 70°C but not at 20°C, that increasing the concentration further up to 3 g-eq./l does not increase the rate of porous layer buildup at 20-70°C but increasing the HCl concentration up to 3 g-eq./l does at 100°C. The results are generally analogous to those obtained in previous studies of other glasses of this class.
The authors thank B.I. Venzel for making the adsorption measurements and O.V. Mazurin, S.P. Zhdanov, and T.S. Tsekhomskaya for valuable comments made during discussion of the results. References 21: 16 Russian, 5 Western (1 in Russian translation).

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PHYSICO-CHEMICAL PROPERTIES OF THALLIUM-BORON SILICATE GLASSES

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 13 Mar 85) pp 591-595

[Article by L.G. Dokhikyan, A.K. Yakhkind, M.B. Krasnopolskaya and A.I. Garkun]

[Abstract] An experimental study of 12 thallium-boron silicate glasses (synthesis 13.84-67.36 Tl_2O + 16.32-71.46 B_2O_3 + 5.57-47.37 SiO_2 — analysis 16.78-61.45 Tl_2O + 14.62-64.12 B_2O_3 + 8.08-53.25 SiO_2, fractions in mol.%) was made, for a systematic determination of their density, refractive index and thermal expansion coefficients. The glasses were founded in quartz crucibles in an electrical resistance furnace at 600-1000°C, with stirring of the melt. Chemical analysis with 4 N H_2SO_4 revealed changes in the composition as a result of volatility of glass components and solubility of quartz. The amount of SiO_2 in the residue was measured by the weighing method. Iodometric titration was used for determination of thallium, after oxidation of Tl^I to Tl^{III} by Br water in a H_2SO_4 medium. The density was measured, within ±0.001 g/cm^3, by hydrostatic weighing in toluene. The thermal expansion coefficients and the glass transition temperature were measured, within $\pm 5 \cdot 10^{-7}$/°C, on a DKV5A vertical quartz-tube dilatometer. The refractive index of most glasses was measured, within ±0.003, by the immersion method under an MIN-8 microscope. The refractive index of immersion fluids had been checked under an IRF454B Abbe microscope (low refractive index) or against reference specimens of tellurite glasses (high refractive index). The refractive index of some glasses, having sufficient chemical stability, was measured with a goniometer. Molar volume and molar refraction of the three glass components, in the Lorentz-Lorenz sense, were calculated on the basis of the "analysis" chemical composition. References 12: 10 Russian, 2 Western.

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UDC 666.117:587.226

PHYSICO-CHEMICAL CHARACTERISTICS OF ELECTROOPTICAL NIOBATE GLASSES

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 14 Oct 85) pp 598-601

[Article by G.O. Karapetyan, Yu.G. Korolev, L.V. Maksamov and S.V. Nemilov]

[Abstract] An experimental study of $xNb_2O_5 + 19Na_2O = 11K_2O + 2B_2O_3 + 2CdO + (66-x)SiO_2$ glasses with x= 29-37 mol.% was made for the purpose of determining some physico-chemical characteristics of phase transformation and its effect on electrooptical properties of these glasses. The glasses were founded in platinum crucibles at 1400°C. Viscosity measurements were made during various

temperature-time cycles for determination of qualitative and quantitative changes. The data reveal an initial "induction" period of constant viscosity followed, after a slow rise of viscosity, by a period of steeply rising viscosity. They also reveal that lowering the Nb_2O_5 content and correspondingly increasing the SiO_2 content lengthens the "induction" period and thus delays crystallization. Specimens of glass with 37 mol.% Nb_2O_5 were heat treated in two isothermal stages: at T_1= 607°C for nominally 4.5 h corresponding to the "induction" period and then at T_2 within the 710-810°C range for 1 h. Deviation from the 4.5 h duration of the first stage resulted in stronger scattering of light by the glass. An x-ray phase analysis of these specimens revealed formation of $NaNbO_3$ pseudocubic microcrystals by this heat treatment, a higher heat treatment temperature T_2 increasing the total volume of the crystalline phase without significantly changing the size of the microcrystals. Absorption of light at λ_1= 450 nm and λ_2= 600 nm wavelengths was measured and both absorption coefficients were found to increase with higher heat treatment temperature T_2. Specimens with lower Nb_2O_5 content were also heat treated, isothermally in two stages, first at temperatures of 607-611°C for 4.5 h and then at 700°C for 1 h. Lowering the Nb_2O_5 content and correspondingly increasing the SiO_2 content was found to increase the size of the $NaNbO_3$ microcrystals and to decrease the total volume of the crystalline phase. The transverse electrooptic effect in these glasses was measured, using 1 mm thick and 10x8 mm^2 large plates with electrodes deposited on the 10x8 mm^2 surfaces for application of a high voltage and passing through the 8x1 mm^2 faces of He-Ne laser beam polarized in a plane at 45° to the direction of the electric field. The half-wave voltage, corresponding to 100% transmission, was found to decrease more steeply with higher heat treatment temperature T_2 and correspondingly larger number of microcrystals than with higher Nb_2O_5 content and correspondingly larger size of the microcrystals. The results of this study indicate that phase transformation in these glasses can produce a fine-disperse crystalline phase which, without appreciably decreasing the transparence to visible light, imparts to them electrooptical properties. The authors thank J.J. Kozhin for recording the x-ray diffraction pattern. References 6: 2 Russian, 4 Western.

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CRYSTALLIZATION OF CHLOROPHOSPHATE GLASSES

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 16 Apr 85) pp 626-628

[Article by T.V. Smirnova and I.P. Alekseyeva]

[Abstract] Crystallization of 19 $Zn(PO_3)_2$-$CdCl_2$-KCl glasses was studied, structural examination by the method of infrared reflection spectra having revealed formation of $(Zn,Cd)_2P_2O_7$ pyrophosphate clusters upon addition of KCl to the $Zn(PO_3)_2$-$CdCl_2$ matrix. Their crystallizability was measured by the standard method, on the basis of polythermal analysis, over a period of

1 h (6 h for least crystallizable glasses) in a furnace with inert gas. Qualitative phase analysis of powder specimens in a DRON-2M x-ray diffractometer with CuK_{α}-radiation source and Ni filter or unicrystal carbon monochromator was supplemented with quantitative x-ray phase analysis of monolithic specimens having sufficiently thick crystalline surface films. The results reveal that the crystallizability of these glasses is lessened by addition of KCl to the $Zn(PO_3)_2$ melt and improved by an increase of the $CdCl_2$ content. The x-ray diffraction patterns indicate that the crystalline phases in most glasses are similar, but very different than the o-$Zn(PO_3)_2$ metaphosphate phase. A crystalline phase containing Cl such as $Cd_5Cl(PO_4)_3$ or KCl, or K_4CdCl_6 at low temperatures of 435-470°C only, was found only in glasses near the borderline of glass formation. References: 1 Russian.

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UDC 666.11.01

MAGNETIC RESONANCE OF ^{27}Al AND ^{31}P NUCLEI IN $K_2O-P_2O_5-xAl_2O_3$ GLASSES

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 12, No 5, Sep-Oct 86 (manuscript received 18 Jul 85) pp 636-637

[Article by A.V. Dmitriyev, Yu.F. Zhuravlev, R.N. Pletnev and V.K. Slepukhin, Chemistry Institute, Ural Science Center, USSR Academy of Sciences, Sverdlovsk]

[Abstract] A study of potassium-aluminum phosphate glasses with variable Al_2O_3 content was made by the NMR method involving ^{27}Al and ^{31}P nuclei for the purpose of determining the mechanism of the structurally and chemically stabilizing effect of Al_2O_3. Four glasses of the $K_2O-P_2O_5-xAl_2O_3$ system were tested, with x= 0.2, 0.4, 0.6, 0.8 respectively, their NMR spectra being recorded at room temperature at two frequencies: 15 MHz for ^{27}Al nuclei and 26 MHz for ^{31}P nuclei. The spectra of ^{27}Al were compared with those of ^{27}Al in α-Al_2O_3 corundum and in $AlPO_4$ berlinite. The results indicate that addition of Al_2O_3 gives rise to dipole-dipole interaction of Al and P atoms, some decrease of ΔH and M_2 being explainable only by an increase of the mean distance between P atoms, Al ions having entered the glass structure in the form of AlO_4 and AlO_6 clusters. Reference: 3 Russian.

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UDC 548.55:546.28

MODELING GROWTH OF INTERDENDRITIC SILICON RIBBONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 22, No 10, Oct 86 (manuscript received 18 Dec 84) pp 1589-1593

[Article by M.Ya. Dashevskiy, B.N. Azarenok and D.M. Kiselev, Moscow Steel and Alloys Institute]

[Abstract] The process of growing interdendritic silicon ribbons by the Czochralski method, for production of Si single crystals with specific surface profiles, is simulated mathematically with a system of two two-dimensional partial differential equations of heat conduction kinetics which describe the temperature distributions in the interdendritic region and in the dendrite frame as functions of time. These equations correspond to the physical model of a crystalline web pulled vertically upward from the melt in a crucible. They include terms accounting for vertical and horizontal heat transfer by conduction from crystal to melt, heat transfer by radiation from web to ambient air, and heat transfer induced by vertical motion of the crystallizing web. The problem is formulated for some initial temperature distribution $T(x,y,0)$ and four boundary conditions: 1) temperature at the ribbon crystallization front equal to the crystallization point of silicon, 2) temperature at the dendrite crystallization front equal to the melt subcooling temperature, 3) negative normal temperature gradient across the dendrite-melt interface, 4) zero normal temperature gradient at the lateral dendrite surface above the melt. The temperature at the upper ribbon edge is assumed to be a linear function of the distance from the ribbon crystallization front below. The problem has been solved numerically by the methods of finite differences with splitting and of difference-elimination. The results reveal, for purposes of process control, that the transverse temperature distribution over both frame and ribbon crystallization fronts depends significantly on the depth of dendrite immersion and on the altitude of the ribbon crystallization front above the melt surface, as well as somewhat on the temperature of the thermal shield around dendrite frame above the melt surface, and negligibly on the temperature distribution in the melt. References 5: 2 Russian, 3 Western.

2415/9716
CSO: 1842/32

UDC 539.216.232:546.28

KINETICS AND MECHANISM OF GROWTH OF POLYCRYSTALLINE Si LAYERS DURING PYROLYSIS OF SiH_4 IN ARGON ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 4 Jan 85) pp 1594-1598

[Article by V.A. Puga]

[Abstract] An experimental study was made concerning the growth of polycrystalline Si layers during pyrolysis of SiH_4 in an Ar atmosphere, with independent measurements of the SiH_4 decrement and the Si increment. A mixture of 4% SiH_4 with H_2 and Ar with less than $7 \cdot 10^{-3}$ Pa water vapor was heated in a tubular quartz reactor to various temperatures covering the 850-920 K range under atmospheric pressure, for decomposition of SiH_4, with the partial pressure of SiH_4 varied over the 20-100 Pa range. The mixture was admitted into the reactor with an initial pressure not higher than 0.1 Pa at a rate of 6.2 l/min, corresponding to a reaction buildup time of 1.16-1.26 s. The thickness of Si layers growing on Si plates with 400-1000 μm thick pyrolytic Si_3N_4 coating was measured by the optical interference method with an error not larger than 10%. The SiH_4 concentration at the reactor outlet was measured by the method of infrared spectroscopy with a UR-20 instrument, within the 800-1100 cm^{-1} band corresponding to the frequency range of deformational vibrations of SiH_4 molecules. Polycrystalline Si layers deposited at temperatures of 900-920 K had a pure mirror surface regardless of the SiH_4 concentration in the gas mixture. Those deposited at temperatures of 850-870 K had a pure mirror surface only when the SiH_4 concentration was low and were covered with a powder substance, the product of SiH_4 decomposition in the gaseous phase, when the partial pressure of SiH_4 exceeded 40 Pa. The longitudinal profile of the Si layer growth rate had a peak at the entrance to the isothermal zone, this peak increasing with higher SiH_4 concentration and decreasing as well as flattening with lower temperature. The results indicate a strong almost linear temperature dependence and a weak pressure dependence of the SiH_4 decomposition rate, the dependence of the Si layer growth rate on the partial pressure of SiH_4 being strong and becoming almost linear at higher temperatures. Quantitative chemical analysis reveals a reaction which changes from a heterogeneous first-order one with an activation energy of 155 kJ/mole at higher temperatures to a homogeneous almost zero-order one with an activation energy of 219 kJ/mole at lower temperatures, with precipitation of powder when the temperature drops below 900 K and the reaction rate also drops. The limiting stage of Si layer growth is splitting away of H_2 from the $=SiH_2$ group at higher temperatures and splitting away of H from the $\equiv SiH$ group at lower temperatures. The author thanks S.M. Repinskiy for discussing the mechanism of SiH_3 decomposition. References 10: 1 Russian, 9 Western.

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EFFECT OF GERMANIUM ON FORMATION OF THERMODONORS IN SILICON

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian
Vol 22, No 10, Oct 86 (manuscript received 18 Dec 84) pp 1599-1601

[Article by M.Ya. Dashevskiy, A.A. Dokuchayeva and K.I. Anisimov, Moscow Steel and Alloys Institute]

[Abstract] An experimental study has indirectly confirmed the hypothesis that doping silicon with germanium increases the solubility of oxygen at temperatures from 450°C up. Two Si single crystals with <111> orientation were grown under identical conditions, one doped with P only and one doped also with Ge to a concentration of 7.3 10^{17}-$1.1 \cdot 10^{20}$ cm^{-3}. Slices containing identical volume fractions of the crystallized phase were heat treated at 450°C in air (thermodonors known to form in Si at this temperature, build up to saturation concentration which can be as high as $5 \cdot 10^{16}$ cm^{-3}, and then relax), one batch annealed continuously for 1140 h and one batch annealed cyclically with intermediate 15 h periods at a higher temperature of 550°C. The Ge concentration before annealing was monitored on the basis of lattice period measurements, assuming Vegard's law to be applicable here. The oxygen concentration during annealing was monitored on the basis of optical measurements by the absolute method with an error not larger than ±15%. Specimens were also periodically quenched at a rate of 300°C/min, for measurement of their electrical resistivity by the voltage-current method with an error not larger than ±10%. The oxide forming at the surface during annealing was removed before these measurements, a 50 μm thick layer, whereupon the fresh surface was etched and polished for resumption of the annealing process. The results of this heat treatment indicate a decrease of the maximum thermodonor concentration and, correspondingly, of the maximum drop of electrical resistivity with increasing Ge concentration. The attendant increase of oxygen solubility with increasing Ge concentration is evidently facilitated by a buildup of vacancies or their associates in the Si lattice, where elastic interaction with the larger Ge atoms produces compressive stresses. References 7: 5 Russian, 2 Western.

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CSO: 1842/32

UDC 620.191:621.315.592.3

SURFACE INSPECTION OF Si SINGLE CRYSTALS BY WETTING-ANGLE METHOD AFTER ION IMPLANTATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 27 Dec 84) pp 1602-1605

[Article by N.N. Lebedeva, V.V. Bakovets, Ye.A. Sedymova and N.B. Pridachin, Inorganic Chemistry Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] For the purpose of facilitating surface inspection of Si single crystals after ion implantation in manufacture of integrated-circuit chips by the planar technology, a relation is established between implantation dose and critical wetting angle. For experimental validation, specimens of Si single crystals were bombarded with ions in the <111> direction: KEF-0.2 silicon with 100 keV boron ions at 25°C and at 400°C in doses up to $2 \cdot 10^{16}$ cm^{-2}; KEF-0.5 silicon with 60 keV argon ions at 25°C in doses up to 10^{16} cm^{-2}. The specimens were then tested for wettability by a resting drop of $(C_2H_5)_2O$ in a pool of deionized water, an almost immiscible pair of liquids with electrical resistivity higher than 7 Mohm·cm, at 20°C and by a resting drop of 99.999% atom.% Sn melt in a hydrogen atmosphere at temperatures of 300-1100°C. Water improves the reproducibility of angle readings, wetting angles of 30-150° being most easily measurable. The critical wetting angle was determined with a KM-6 cathetometer. The results of the low-temperature experiment confirm that wettability of Si by a $(C_2H_5)_2O$ drop in water is a reliable indicator of surface defectiveness caused by ion implantation, boron ions causing more severe changes in the properties of a Si surface than do argon ions. The results of the high-temperature experiment, with specimens heated from 300°C to 1100°C in 25°C steps, indicate that annealing at 550-700°C most effectively cures defects caused by ion implantation and restores the preimplantation surface state. The authors thank N.N. Gerasimenko for helpful discussion, and B.M. Ayupov and N.P. Sysoyev for measuring the thickness of oxide surface films with an ellipsometer. References 9: 6 Russian, 3 Western (2 in Russian translation).

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UDC 541.65

OPTICAL AND PHOTOELECTRICAL PROPERTIES OF ANODIC OXIDE FILMS ON GaAs, GaP, AND $GaAs_{0.6}P_{0.4}$

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 23 Jan 85) pp 1606-1609

[Article by P.K. Kashkarov, A.N. Obraztsov, I.N. Sorokin and Yu.N. Sosnovskikh, Moscow State University imeni M.V. Lomonosov and Moscow Electronic Engineering Institute]

[Abstract] Optical and photoelectrical properties of anodic oxide films on the surface of n-GaAs single crystals ($n= 10^{18}$ cm^{-3}), epitaxial p-GaP layers ($p= 10^{18}$ cm^{-3}), and epitaxial n-$GaAs_{0.6}P_{0.4}$ layers ($n= 10^{17}$ cm^{-3}) were measured after oxidation in a cold electrolyte consisting of organic solvents with 5-10 wt.% H_2O and an organic acid as electrical conductor. All specimens were annealed at a temperature of 520 K in an argon atmosphere. The film thickness and the refractive index were measured by the ellipsometric method at the $\lambda = 633$ nm illumination wavelength. Structural examination was done by the electron-diffraction method. Absorption of visible and near-ultraviolet light was measured by the comparison method, the cold (80 K) photoluminescence excitaton spectra of oxidized specimens being compared with those of specimens from which the oxide film had been etched away by means of an HCl agent. The reflection spectra of both sets of specimens were also measured, for the purpose of determining and correcting for the interference effect. The apparatus consisted of a DKSSh-1000 superhigh-pressure xenon lamp with an MDR-2 monochromator as excitation source, an MDR-23 monochromator with deep-cooled FEU-23 and FEU-106 photon counters for recording. Photoconduction at a temperature of 300 K through MOS structures which had been produced by deposition of translucent Al-electrodes on the anodic oxide films under a vacuum of 10^{-4} Pa was measured separately under a vacuum of 10^{-3} Pa with a V7-30 electrometer, using the same photoexcitation source and a B5-7 d.c. voltage source. The photoluminescence excitation spectra were measured at three lines: 1.23 eV (GaAs), 1.85 eV (GaP), 2.0 eV ($GaAs_{0.6}P_{0.4}$). The results indicate that the anodic oxide film has in each case a 4.9±0.1 eV absorption edge (optical width of forbidden band) and a 4.2 eV photoconduction threshold (energy gap between density-of-states "tails"). The authors thank V.F. Kiselev and Yu.A. Zarifyants for discussion and valuable comments. References 10: 2 Russian, 8 Western (2 in Russian translation).

2415/9716
CSO: 1842/32

UDC (546.48'22+546.47'22):539.216.2

STRUCTURE OF EPITAXIAL CdS AND ZnS FILMS PRODUCED FROM CHELATE ORGANOMETAL COMPOUNDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 22 Jan 85) pp 1621-1624

[Article by L.V. Zavyalova, A.S. Nichiporovich, G.S. Svechnikov and N.M. Torchun]

[Abstract] For a strucutral examination of epitaxial CdS and ZnS films produced from chelate organometal compounds, such films were grown from a 0.1 M solution of an organocadmium or organozinc compound on various substrates at a temperature of 260-270°C. Sphaleritic β-ZnS single crystals with 10% twinning defects, grown from a melt in an argon atmosphere under a pressure of 10-20 MPa, and mica sheets were used as substrates. All light-yellow opaque CdS films and colorless transparent ZnS films were 0.6-0.8 um thick with a mirror surface and with grains of the $(1-2)\cdot10^3$ Å size, their adhesion strength of 500-1500 N/cm^2 depending on the material and the surface finish of the substrate. Structural examination of both substrate and film was done in a fast-electron reflection diffractometer. The results revealed the sphaleritic β-phase and the wurtzitic α- phase, each alone or both together, in the condensates. The orientation of the condensate films was found to be influenced, but differently, by the polar axes A <111> and B <111>. Both β-ZnS and α-CdS are known to be thermodynamically stable at temperatures near 300°C. The appearance of metastable β-CdS and α-ZnS in the condensates, whic has been attributed to high supersaturation, is probably caused by the epitaxial growth becoming a nonequilibrium process and by attendant mechanical stress, as well as formation of metal-sulfur complexes in high-energy electron-vibrational states on the substrate. Transition of these complexes to the ground state during crystallization releases energy and local heating results, sufficient for phase transformation. References 8: 6 Russian, 2 Western (both in Russian translation).

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CSO: 1842/32

UDC 535.37

LUMINISCENCE SPECTRA OF BINARY GALLIUM AND RARE-EARTH CHALCOGENIDES WITH NEODYMIUM CONTENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 22 Jan 85) pp 1630-1634

[Article by G.K. Aslanov, Ch.M. Briskina, V.F. Zolin, V.M. Markushev, G.M. Niftiyev and O.B. Tagiyev, Radio Engineering and Electronics Institute, USSR Academy of Sciences]

[Abstract] Since the solubility of Nd in Ga_2S_3 and Ga_2Se_3 is very low, evidently owing to the very different sizes of Nd and Ga ions, binary chalcogenides of Ga and a rare-earth element in the lanthanides series are considered instead for attainment of higher Nd solubility. For an experimental study of this problem, crystals of four such compounds ($EuGa_2S_4$, $EuGa_2Se_4$, $YbGa_2S_4$, $YbGa_2Se_4$) were grown by the method of chemical transport reactions while metallic Nd was added in amounts of 0.003-1 atom.%. They were then excited at three temperatures (4.2, 77, 300 K) with a dye laser tunable over the 540-700 nm wavelength range and with a $LiF+F^+$-centers laser tunable over the 840-1040 nm wavelength range, both being pumped by second-harmonic radiation from a YAG:Nd^{3+} laser in pulses of 30 ns duration. Luminescence spectra were recorded with a 1 μs time resolution, by means of an MDR-23 monochromator and an FEU-83 or FEU-79 photomultiplier with a VSI-280 integrator. Their dependence on the excitation wavelength indicates the existence of several nonequivalent luminescence centers and confirms the theory that injected Nd^{3+} ions replace Eu^{2+} and Yb^{2+} ions. The spectra of intracenter luminescence of Nd^{3+} ions and of wideband glow of host crystals excited by band-to-band transitions indicate, moreover, that Nd^{3+} ions become excited through intermediaries: probably Eu^{2+} ions in $EuGa_2Se_4$ at room temperature and traps with weaker wideband glow at lower temperatures. Measurements have revealed that luminescence of Nd in a $YbGa_2S_4$ crystal has an intensity which increases with increasing pump power, at any temperature, but only up to a saturation level dependent on the temperature. References 8: 5 Russian, 3 Western.

2415/9716
CSO: 1842/32

UDC 620.18:669.26'25'3:669.018.58

EFFECT OF PRELIMINARY AGING AND FLAT ROLLING ON STRUCTURE AND MAGNETIC PROPERTIES OF Fe-Cr-Co-Cu ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 54-56

[Article by B.A. Samarin, A.Ye. Kolchin and Yu.V. Kalner, Moscow Steel and Alloys Institute]

[Abstract] An experimental study of the 53% Fe+ 33% Cr+ 12% Co+ 2% Cu permanent-magnet alloy was made for the purpose of determining the effect of preliminary strain aging and flat rolling before the second strain aging on its structurization and magnetic properties. Two modifications of this alloy were included in the study, one with 1% Al added and one with 2% Nb added. These alloys were produced by smelting in an induction furnace in an argon atmosphere. Ingots weighing 1 kg were forged at 1200-1250°C into square bars with 10x10 mm^2 cross-section. The bars were quenched into a homogeneous α-phase solid solution from 1050°C (Fe-Cr-Co-Cu alloy), 1000°C (1% Al) and 950°C (2% Nb). Preliminary strain aging after quenching, at a temperature decreasing fast from 650°C to 600°C, was followed by cold rolling up to, but not more than, 80% reduction in a single-stand mill with flat rollers. Second strain aging followed at a temperature decreasing first slowly from 600°C to 550°C and then more slowly from 550°C to 500°C. The cooling rate during preliminary strain aging was varied from 30°C/h to 50°C/h. The microstructure of the α-phase after quenching was examined under an optical microscope. The structure of high-coercivity material after strain aging and intermediate cold rolling was examined under a "Tesla BS-540" electron microscope; x-ray structural and phase analysis was done with a CrK_{α}-radiation source. The results indicate that addition of Al or Nb decreases the grain size of the α- phase after quenching and thus facilitates plastic deformation during the intermediate cold rolling, with a Laves phase appearing in the alloy with 2% Nb, and that preliminary strain aging causes precipitation of a strongly magnetic α_1-phase (FeCo) whose grains remain equiaxial in form but decreases in size as the cooling rate is increased. The best magnets were obtained by preliminary aging with a cooling rate of 50°C/h, cold rolling to a 67% reduction of thickness, and second aging with cooling first at a rate of 15°C/h and then at a rate of 8°C/h. References 5: 2 Russian, 3 Western.

2415/9716
CSO: 1842/25

UDC 669.295'784.669.275'784.669.269'784

SPHEROIDIZATION OF CARBIDES OF SOME TRANSITION METALS IN LOW-TEMPERATURE PLASMA

Moscow FIZIKA I KHIMIYA OBRABOTKI METALLOV in Russian No 5, Sep-Oct 86 (manuscript received 2 Apr 85) pp 74-77

[Article by N.A. Klinskaya, Ye.B. Koroleva, V.A. Petrunichev, O.F. Rybalko, P.V. Solovyev, and T.A. Ugolnikova, Moscow]

[Abstarct] In an experimental feasibility study TiC, Cr_3C_2, WC carbide powders of 40-80 μm grain size fraction were spheroidized in a UPSP-1 apparatus with a segmental plasmotron, using grade-A argon (not more than 0.003% O_2, 0.01% N_2, 0.03 g/m^3 water vapor) as both plasma forming and powder transporting gas. With the temperature of the plasma jet 10,500 K in the nozzle, the useful powder to the hermetic processing chamber was varied over the 54-80 kW range to suit the particular carbides. The flow rates of plasma forming and powder transforming argon were 3.2-3.7 m^3/h and 0.35-0.5 m^3/h respectively, while the rate of powder feed to the nozzle was varied over the 20-50 g/min range. Granulometric and phase analysis of initial materials and final products revealed compaction to a high density with attendant enlargement and rounding of grains, this process becoming less effective with increasing grain size. Chemical analysis yielded the amounts of free and bound carbon. Spheroidization levels of 23-70% (TiC), 32-67% (Cr_3C_2), 40-78% (WC), depending on the grain size fraction within the 40-80 μm range, were attained by this process. References: 8 Russian.

2415/9716
CSO: 1842/39

UDC 661.887-911.6:531.3:548.3

MECHANISM AND KINETICS OF $Bi_{12}TiO_{20}$ SYNTHESIS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 3 Jan 85) pp 1701-1704

[Article by A.V. Kosov and V.Yu. Yendrzheyevskaya, Krasnoyarsk State University]

[Abstract] The mechanism and the kinetics of $Bi_{12}TiO_{20}$ solid-phase synthesis from Bi_2O_3 and TiO_2 powders were studied in an experiment, with the two extra-pure oxide calcined from 8 h at 950 K and 1370 K respectively before being mixed in a 6:1 ratio. Isothermal synthesis at temperatures varied from 920°C to 1100°C took place in air or at various levels of partial oxygen pressure under dynamic conditions, and was followed by annealing at 930-1100°C. The results of differential thermal analysis, high-temperature x-ray phase analysis, and local x-ray spectral microanalysis indicate that both the monoclinic α-Bi_2O_3 and the high-temperature δ(f.c.c.)-Bi_2O_3 participate in synthesis of $Bi_{12}TiO_{20}$, with $Bi_4Ti_3O_{12}$ also forming as a byproduct. The

process of synthesis begins with diffusion of Bi^{3+} ions (radius 1.20 Å) into the TiO_2 (rutile) lattice and their migration along O^{2-} -vacancies (radius 1.36 Å) in that lattice, with Ti^{4+} ions (radius 0.64 Å) playing a secondary role. This is confirmed by a decrease of the $Bi_{12}TiO_{20}$ yield with increasing partial oxygen pressure and consequently decreasing vacancy concentration in the TiO_2 lattice. References 10: 6 Russian, 4 Western (1 in Russian translation).

2415/9716
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UDC 536.7+541.141

PHYSICOCHEMICAL AND PHOTOELECTRIC PROPERTIES OF Cd_4GeS_6, Cd_4GeSe_6 CRYSTALS AND $Cd_4Ge(S_{1-x}Se_x)_6$ SOLID-SOLUTION CRYSTALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 10, Oct 86 (manuscript received 20 Dec 84) pp 1705-1708

[Article by S.F. Motrya, V.I. Tkachenko, V.M. Chereshnya, A.A. Kikineshi and Ye.Ye. Semrad, Uzhgorod State Univesity]

[Abstract] An experimental study of Cd_4GeS_6, Cd_4GeSe_6 crystals and $Cd_4Ge(S_{1-x}Se_x)_6$ solid-solution crystals was made for a determination of their physicochemical and photoelectrical properties. They were synthesized from stoichiometric mixtures of Ge + S + CdS, Ge + Se + CdSe, and Ge + S + CdS + Se + CdSe respectively at appropriate temperatures within the 1070-1125 K range and with use of a vibratory blender. All ingredients had been purified by zone melting and vacuum sublimation. Crystals were grown by the method of chemical transport reaction, with 4-5 mg/cm^3 $V4$ iodine as transporting agent, at temperatures of 790-860 K in the evaporation zone and 720-785 K in the crystallization zone. Crystals were identified by chemical analysis as well as by phase analysis in a DRON-0.5 x-ray diffractometer with CuK_α-radiation source and Ni filter. Physical measurements included: the mean low-temperature (77-298 K) specific heat in a ballistic Calvet microcalorimeter; the standard entropy of polycrystalline compounds, entropy and enthalpy of crystallization; photosensitivity in the visible range of the spectrum; electrical resistivity; photoconduction current and dark current through crystals between Au-electrodes; photoconductivity activation energy; and drift mobility of holes and electrons under excitation by a pulse of highly absorbable light. The data were used for calculating, with the aid of tables of the Einstein function, the dependence of the characteristic temperature on the low-temperature mean specific heat, disregarding the small difference between c_p and c_v, also for plotting the photoconduction spectra. The results indicate existence of a continuous series of Cd_4GeS_6-Cd_4GeSe_6 substitutional solid solutions, their physicochemical and photoelectrical properties being monotonic functions of the S or Se content. Their photosensitivity and electrical resistivity, for instance, decrease with increasing Se content. References 10: 3 Russian, 7 Western (1 in Russian translation).

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CSO: 1842/32

GAS EXTRUSION OF METALS

Moscow ZNANIYE-SILA in Russian No 10, Oct 86 p 6

[Article by A. Ruvinskiy under the "Discussions on Technical Progress" rubric: "Gas and Metal"; first paragraph printed in italics]

[Text] Gas extrusion. What does the new metalworking method offer? It permits modification of metal properties and production of articles with predetermined properties. Today, continuous metalworking processes; tomorrow, controlled processes.

Success! A finished article, as if custom-made, comes out of a high-pressure cylinder. For example, it may be a thin metal rod. Machining it from a conventional blank is difficult and produces a lot of scrap.

Extrusion means pressing out. A blank is forced through a special device--a thick-walled cylinder that tapers down in the shape of a funnel and ends with a still narrower channel. The entire mass of the metal should pass through this channel, if . . .

Hot extrusion was mastered already in the last century, and this metalworking method has competed with traditional methods such as forging and die forging. The extrusion press and the extrusion cylinder have been found over dozens of years to be reliable and trouble-free. There is one drawback--friction has always been a problem. It consumes a lot of energy. Also, when the metal rubs against the cylinder walls, plastic deformation becomes nonuniform, and this lowers the properties of the extruded material. And brittle materials simply break. Various methods of combatting friction were developed. A liner was needed that would reduce friction and aid the metal in its motion towards the narrow channel without any great obstacles. At first liquids were proposed for this purpose--mainly various oils--and later inert gas. In the former case this metalworking method was called hydrostatic extrusion, and in the latter case, gas extrusion. In all probability, gas extrusion has a great future. But the road to gas extrusion was strewn with obstacles, and much remains to be done in order to master this technology.

Let us scan some pages of the history of the work of scientists in the area of this advantageous technological method.

Flame and press. This is the very beginning of the history of hot extrusion. Here it is: a hot blank, straight out of the furnace, is spewing heat. It is quickly transferred into the cylinder and under the press. But friction is still present here . . .

Fluid and press. All efforts were exerted to combat friction. Oil was pumped into the high-pressure cylinder, and no heat was employed. It was thought that the ductility of the metal would increase as a result of a high and uniform hydrostatic pressure on the blank. The experiments carried out in the 1960s were unsuccessful. In most cases, the metal coming out of the channel cracked. Later, high-quality articles were produced thanks to the studies of L. F. Vereshchagin and B.I. Bersenev of the USSR Academy of Sciences High-Pressure Physics Institute. Similar results were also obtained by English physicist G. Pew of the National Enginering Laboratory. The prospects of the new method became brighter in the early 1970s, but still it was possible to merely double, or at most triple, the length of a blank. Attempts at still higher degrees of extrusion resulted in cracking of the blanks. And the cost of not heating the blanks was the use of immense pressures, up to 20,000 atmospheres. Such high pressures are inconvenient and unsafe under production conditions.

Fluid and flame. Should one return to high temperatures? They will soften the metal and increase its ductility. The metal blank again blazed from heat. But now it was heated not in the furnace but in the high-pressure cylinder itself. There was a new surprise. The liquid, the same liquid that had become the foundation of the new method, could not stand the heat and decomposed into its component parts, boiled, rebelled, and became corrosive. A replacement had to be found.

Gas and flame. The replacement found was inert gas. It was brought back to mind by the workers of the High-Pressure Physics Institute. They remembered its use in hot presses in the melting and forging of metals. The scientists devoted themselves to the study of the new process--high-temperature gas extrusion. A special laboratory appeared in the High-Pressure Physics Institute. It was headed by Vladimir Demyanovich Berbentsev. The task was to translate the idea into industrial technology.

The puzzle of gunshots. Gas at a pressure of 10 atmospheres was introduced from a compressor into the high-pressure cylinder. Higher pressures were impossible because 10 atmospheres was the limit for the steel from which the cylinder was made. Everything was calculated. But the reduced part of the blank tore off at the exit from the cylinder and flew out with a great velocity. A shot accompanied each experiment. V. D. Berbentsev looked for the cause of these shots for about four years. For a time he was in utter despair. Everything had gone wrong.

Sometimes the response of scientists to the question of how they had found a solution is "Well, there was a moment . . ." Vladimir Demyanovich also had "such a moment." "We heat the part of the blank that is between the cylinder walls," he thought. "And the part near the point where the cylinder becomes narrow, where ductility is especially important, remains cold. The

hot mass of metal tries to go through a narrow opening, which is essentially a cold or slightly heated plug. It goes through, of course, but with what stress! And wherever the stresses are very high, the blank accelerates. Upon acceleration, the far portion of the blank tears off. It tears off suddenly, with a bang. This is what causes the gunshot!"

The moment arrived and a solution was found: The blank should be heated primarily at the point where it should be most ductile. This is where the metal should be pliable and soft.

And so, success!

At first soft metals (aluminum, copper) were extruded, and later, harder ones (steel, titanium alloys). Hot gas passed the test beautifully. Excellent articles began to come out of the high-pressure cylinder.

You have glanced at five pages of the history of a technological method. At first practical workers and, starting in the 1950s, prominent scientists conducted experiments, made calculations, and expressed ideas. And at the first glance the solution appears to be so simple. But the complex history of the gas extrusion method demonstrates very well the contribution of science to the development of practical methods. High-pressure physics . . . Here a scientist-physicist also plays the role of a blacksmith, and this is a title of esteem. But the history of extrusion is far from complete. These are merely the first five pages.

The chief advantage of gas extrusion is the fact that the required temperature is known in advance for each metal, and that the rate of the process can be varied by varing the heat input; this makes it possible to vary the properties of the material.

Thin metal rods are irreplaceable raw materials for the production of small-size tools such as drill bits and taps. Thus far, they are most frequently machined from thick rods. Naturally, this wastes a lot of the material. On the other hand, it is easy to produce rods of any desired diameter by the gas extrusion method, and drill bits made from these rods have a very high quality. A multitude of problems is also eliminated in wire production.

With the old wire production method (drawing), the metal at the wire surface is weak and impoverished in carbon and alloying elements. This layer has to be removed by grinding, which is time consuming and produces waste. The new method, on the other hand, does not produce this impoverished layer!

But this is how things stand in the laboratory of the scientific-research institute. And what about outside the institute? Can one expect a speedy utilization of high-temperature gas extrusion at industrial enterprises?

Vladimir Demyanovich shows a letter to the institute from the Yaroslav Diesel Equipment Plant:

". . . The plant has studied high-speed steel blanks, including tungsten-free blanks, made with the use of the high-temperature gas extrusion technology on extruders of the USSR Academy of Sciences High-Pressure Physics Institute and has conducted preliminary testing of drill bits made from these blanks. The results are positive."

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DETERMINATION OF LASER HEATING PARAMETERS FOR HARDENING CARBON STEELS TO GIVEN CASE THICKNESS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 32-35

[Article by Ye.A. Dubrovskaya, Ch. V. Kopetskiy, V.S. Kraposhin and I.V. Rodin, IPTM [expansion unknown], USSR Academy of Sciences]

[Abstract] The problem of determining the laser heating parameters for hardening steel and cast iron to a given case thickness, upon austenitization, has been solved analytically on the basis of the model of one-dimensional heat conduction through a homogeneous, semi-infinitely large, body. According to this model, the thickness h of the layer thus hardened without sweating is a function of the quantity $W/\sqrt{Dv}$ (W- laser output power, D- diameter of laser spot on the treated surface, v- linear velocity of laser beam scanning the treated surface). For each grade of steel or cast iron one needs to determine two constants: $A= h_{sw}/\sqrt{\tau_{sw}}$ and $B= q_{sw}\sqrt{\tau_{sw}}$ ($q= rW/\pi D^2$ - power density of laser radiation, $\tau = D/v$ - duration of treatment by continuous-wave laser, subscript sw referring to point of transition from hardening with to hardening without sweating). The constancy of B is predicated on the constancy of the surface temperature $T(0,\tau)$, at the melting point, and its value depends on the carbon content in steel or cast iron. The constancy of A is predicated on a depthwise temperature profile T(z,t) equal to the product of $T(0,\tau)$ by the first-order integral of the error function $\text{erfc}\{z/2\sqrt{a\tau} = 1- \text{erf}\{z/2\sqrt{a\tau}\}$ (a- thermal diffusivity). With both constants known and with the additional constraint that the duration of laser treatment not exceed the time for minimum stability of austenite so as to ensure a higher than critical cooling rate for attainment of a martensite structure, it is possible to select the laser heating mode for hardening to the maximum case depth. The adequacy of this model and the correctness of this procedure were verified experimentally on St20, St45 plain carbon steels and U8 shock-resistant tool steel with treatment by an 800 W transverse-excitation CO_2-laser. The specimens, in "as delivered" condition, were covered with a thin layer of lampblack to maximize the thermal absorptivity. The heating period did not exceed 0.1 s for all three steels so that the cooling rate was higher than critical. The results reveal a change in the shape of the laser track upon transition from hardening with to hardening without sweating. They also confirm the expected microhardness profile across the case including a 250 μm thick transition layer with

variable degree of austenite homogenization between the 400 μm thick martensitic surface layer and the ferritic parent structure. References 3: 2 Russian, 1 Western.

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STRUCTURE AND MECHANICAL PROPERTIES OF THICK BLANKS OF MARTENSITICALLY AGING STEELS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 41-43

[Article by N.B. Gorbunova, V.M. Kardonskiy, P.P. Mukhina, G.Ye. Mysina and V.S. Pakuleva, Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin and Chelyabinsk Metallurgical Combine]

[Abstract] Martensitically aging steels offer advantages over other high-strength materials but they have so far been realized only in blank parts not thicker than 50 mm. Fast cooling of thicker blanks after hot working is not possible and, therefore, their mechanical properties become degraded owing to recrystallization of austenite with attendant precipitation of embrittling excess phases. An experimental study of these processes in martensitically aging high-W or high-Mo alloy steels such as the Ni17Co10W10MoTi (EP836) steel was made for the purpose of solving this technological problem. Specimens of this steel were hot worked, selective recrystallization found to begin above 950-1000°C and slowing down at 1050°C before becoming very rapid at 1100°C with size 1-2 austenite grains appearing at 1200°C. Dependence of this dynamic recrystallization on the mass (thickness) of specimens was tracked on the basis of phase analysis under an electron microscope. The results indicate how far below 1200°C hot working must be ceased so as to prevent excessive austenite grain growth, and that even faster cooling of thick blanks will not prevent precipitation of embrittling phase and thus degradation of mechanical properties. A technology has therefore been developed for producing blanks of this steel with minimum degradation of mechanical properties. The steel is produced by smelting of 01ZhR iron with pure alloying elements, then trimming of the ladle and resmelting in an electric-arc furnace. Ingots are hot worked up to 1200°C and then forged into blanks, those being subsequently machined to final dimensions. The process has been modified first by changing the chemical composition, namely decreasing the amounts of ingredients which lower the martensite transformation temperature, then by regulating the homogenization as well as the thermomechanical treatment so as to prevent striation and to build up immunity against embrittlement during slow cooling. Precise control was found to be both necessary and effective, upon specification of the lower limits for the mechanical properties of blanks. References: 4 Russian.

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INTERACTION OF THERMAL-INSULATION COATING AND STEEL SURFACE DURING HIGH-TEMPERATURE ANNEALING OF ELECTRICAL-GRADE STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 86 pp 52-54

[Article by R.B. Puzhevich, V.G. Borisenko and L.A. Shvartsman, Ural Scientific Research Institute of Ferrous Metallurgy and Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin]

[Abstract] The last two treatments in production of cold-rolled grain-oriented electrical silicon steels are decarburization in a H_2-H_2O-N_2 atmosphere, during which a SiO_2 film forms at the surface, followed by high-temperature annealing at 1150-1200°C with MgO or $Mg(OH)_2$ powder deposited on the surface for both thermal insulation (to prevent layers of steel strip or sheet wound into reels from getting welded together) and electrical ground insulation. Interaction of that powder and the SiO_2 film during high-temperature annealing was studied in an experiment with electrical steel containing 2.8-3.2% Si. Formation of Mg_2SiO_4 (forsterite) by chemical reaction was found to follow oxidation of silicon at the steel surface by water vapor in the decarburizing atmosphere and later in the $MgO+H_2O$ layer, with almost no oxidation of the iron which has diffused into the coating and with slight, up to 10 μm deep, penetration of Mg_2SiO_4 into the steel. References 4: 3 Russian, 1 Western (in Russian translation).

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UDC 669.187.669.063.8

THE HOMOGENIZATION OF STEEL WITH ARGON BLOWING IN THE LADLE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 25 Oct 85) pp 46-50

[Article by V.G. Kadukov, A. Ye. Kogan, N.A. Fomin, M.B. Orzhekh and Ye. F. Demichev, Kuznetsk Metallurgical Combine]

[Abstract] Direct tests were performed to evaluate the minimum duration of argon blowing required to homogenize electric-furnace steel in a 130-ton ladle. Five melts were tested. During the first three, the argon was injected into the melt through expendable refractory-lined lances with a 40-mm bore. During the last two melts, the argon was supplied through experimental lances that had slotted conical nozzles. During the first two melts, the lances were inserted to a depth of 2.1 meters, and the argon was injected at a rate of 30±5 and 70 ±5 m^3/hour. During the third melt, the lance was inserted to a depth of 1.2 meters for the first seven minutes and 2.1 meters for the last three minutes, and the argon was supplied at a constant rate of 70±5 m^3/hour. During the fouth melt, the slotted-nozzle lance was inserted to 2.7 meters and

the argon blown at a rate of 30 m^3/hour. During the final melt, the conical-nozzle lance was inserted to 1.5 meters, and the argon blown at 40 m^3/hour. The melts lasted from 4.5 to 10.25 minutes. Copper was used to indicate when the steel had completely homogenized. One or two copper pigs weighing a total of 100 to 120 kilograms were put into each bath and allowed to melt before commencing the argon blow. Samples of the steel were taken before blowing and at intervals of 1.5 to 4.0 minutes during the blow. All the samples were analyzed on a "Polivak" quantometer. When the copper was uniformly distributed throughout the melt, the steel was considered homogenized. Of the first three melts, only the first became homogenized, and the crucial variable was the length of the blow. The steel homogenized at a much faster rate when the slotted and conical nozzles were used on the lances. Because the cooling rate is affected by the length of the blow, it should be taken into consideration when deciding on the time required to homogenize the steel. References 9: 5 Russian, 3 Western, 1 East European (in Russian translation).

13050/9716
CSO: 1842/37

UDC 669.15--194:62.785.5

SURFACE HARDENING OF CARBON STEELS WITH ELECTRIC-DISCHARGE ALLOYING

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 19 Jul 85) pp 82-84

[Article by V. Ye. Bochkov, Kama Polytechnical Institute]

[Abstract] The nature of the transformations that occur when the surface of a steel is electric-discharge alloyed with tungsten was studied. Specimens of 45, U8, and U13A steels were surface-hardened on an EFI-46A unit. The energy of a single discharge was 0.042 joules, the total duration of the process was $18 \cdot 10^5$ sec., and the electrode passed three times over the one square meter of surface being hardened. The microstructure of the surface layers was examined under a Neophot-2 optical microscope using chemical and thermal etching and also under a JSM-35 scanning electron microscope utilizing reflected electrons. Elemental distribution was studied using a Cameca MS-46 microanalyzer, a Camebax-MBX scanning electron microscope equipped with an x-ray spectrometer, a PHI-540 Auger spectrometer, and a Cameca IMS-300 mass spectrometer. Phase analysis was performed on a DRON-2.0 diffractometer and on a nuclear gamma resonance analyzer developed by MIFI. Microdurometric analysis and standard tests were used to determine wear and scratch resistance and the durability of the hardened specimens. An analysis of the accumulated data showed that hardening occurred as a result of the formation of a supersaturated solid solution of tungsten, oxygen, carbon, nitrogen (in order of decreasing concentration) in alpha-iron and also as a result of the formation of dispersed particles of complex oxides such as $FeWO_4$ tungstenites and twin eta-carbides of the Fe_3W_3C--Fe_4W_2C type. Carbon content determined whether the supersaturated solutions or the eta-carbide phases would predominate. Using this alloying method, it was possible

to increase microhardness to 8.6 HPa for 45 steel, 10.2 for U8 steel, and 11.4 for U13A steel. It was also possible to increase the wear resistance of electric-discharge alloyed steels. References: 9 Russian.

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CSO: 1842/37

UDC 669.14.018.234:669.046.516

THE EFFECT OF SELENIUM MODIFICATION ON THE PROPERTIES OF PIPELINE STEEL

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 11 Mar 86) pp 149-150

[Article by M.I. Gasik, Ch.D. Ismailov and O.I. Polyakov, Dnepropetrovsk Metallurgical Institute]

[Abstract] The effect of adding selenium to type-20 pipeline steel was studied. Ferroselenium (50% Se) was added to ingots of steel made in a 250-ton open-hearth furnace. Enough selenium was added to obtain Se concentrations of 0.01, 0.02, and 0.03% by mass in the metal used to make the pipe. In order to distribute the selenium evenly throughout the ingot, the selenium was dispensed from a thin-walled metal pipe segmented along its length and placed vertically in the ingot mold. Three of 12 ingots in the same bed were treated with Se. Lengthwise specimens 219X8 mm were cut from the pipe made from the selenium-treated steel and subjected to metallographic analysis. In the untreated metal, the sulfide phase appeared as strongly deformed manganese sulfides. In the treated steel, the sulfur was a constituent of weakly deformed manganese sulfoselenides, which achieved minimum deformability with an MnSe concentration of 25%. The mechanical properties of the experimental steel remained high, and pipe made from this steel should show increased resistance to hydrosulfuric substances. References: 2 Russian.

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CSO: 1842/37

UDC 621.791.945

OPTIMIZATION OF OXYGEN CUTTING PROCESS FOR TITANIUM ALLOYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 9, Sep 86 pp 3-4

[Article by V.I. Trusov, engineer, V.V. Khilchevskiy, doctor of technical sciences, and A.Ye. Goldshteyn, engineer, Kiev Polytechnical Institute imeni Semicentennial of the Great Socialist October Revolution]

[Abstract] For the purpose of minimizing the waste of metal in oxygen cutting of high-price titanium alloys, a mathematical model is constructed that adequately describes the dependence of the depth of cut H on the oxygen pressure p and on the velocity v of torch movement. The model is based on a factorial experiment with a rectangular bar of length L and a regression equation for $H= f(v,p)$. The cutting speed is varied over the 0.2-1.2 m/min range in 0.1 m/min steps, and the depth of cut H as well as the loss of mass Δm in each lengthwise pass are measured. The breadth of cut is then calculated as $B= \Delta m/\rho LH$ (ρ- density of the material). The oxygen pressure is determined from the regression equation

$$H=e^{C_1+ C_2v+ C_3v^2+ C_4/p+ C_5/p^2+ C_6v/p+ C_7(v/p)^2}$$

with the coefficient $C_1,\ldots,C_7$ evaluated by the method of least squares. The resulting quadratic equation for $p= f(H,v)$ can be solved on an Elektronika BZ-34 programmable microcalculator with extra memory capacity. The ultimately sought dependence of the breadth of cut B on the oxygen pressure p and the cutting speed v is then determined from the equation $B= D_1 + D_2/v+ D_3/v^2+ D_4p+ D_5p^2+ D_6p/v+ D_7(p/v)^2$ approximating the $B = f(p,v)$ relation, with the coefficients $D_1,\ldots,D_7$ also evaluated by the method of least squares. Now the breadth of cut, and thus the loss of mass, can be minimized by selection of optimum p and v for every depth of cut H according to the "golden section" rule. The procedure has been programmed in FORTRAN on a YeS-1022 computer for cutting the VT-22 titanium-tungsten alloy with an RM-ZI-330 oxygen torch. References 3: 2 Russian, 1 Western (in Russian translation).

2415/9716
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UDC 621.791.495.035

HIGH-PRECISION PHOTOELECTRIC READOUT DEVICE FOR FLAME CUTTING MACHINES

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 9, Sep 86 pp 7-8

[Article by V.M. Sitnichenko, candidate of technical sciences, Ye.G. Dubinin, engineer, and F.M. Malkis, engineer, Kislorodmash Scientific-Production Association, Odessa]

[Abstract] A high-precision readout device for photoelectric control of flame cutting machines has been developed which tracks the white field and the black field on the master form with a rotating light beam. Light passes through a converging lens and then through a slot in a modulator disk rotating at a speed of 3000 rpm. A phototube operating within its linear range converts the periodically appearing light beam into an electric signal. This signal passes through a power amplifier and then a capacitor, for filtering out the d.c. component, to a phase-inverting transistor with bilateral output. From here the direct signal and the inverted signal, after restoration of the d.c. component with subsequent clamping at the "white" level and the "black" level respectively, are sent to an operational amplifier-comparator. The comparator output voltage jumps when both input voltages are equal, when the center of the light beam crosses the boundary between white field and black field. The amplitudes of the two inputs signals change equally upon a change in brightness and contrast, but the instants of time at which they are equal correspond to points on one and the same vertical straight line. Their phase, meanwhile, can be maintained constant by electrical circuit design over a wide range of amplitude variation. References: 2 Russian.

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EFFICIENCY OF FUSION DURING PERIODIC-PULSE LASER-BEAM WELDING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 9, Sep 86 pp 9-10

[Article by G.I. Levin]

[Abstract] Welding of steel with a periodic-pulse laser beam, generally done with a CO_2-laser or a solid-state laser, is analyzed for the purpose of process optimization. There are four basic parameters of a periodic-pulse heat source which independently govern the response of the target metal: average power and pulse power, pulse duration and pulse repetition rate. This provides four degrees of freedom for control, as compared with only one degree of freedom available (power) for control of a continuous-wave laser. This advantage can be utilized for maximizing the efficiency of metal fusion, while also the mode of heat supply to the thermal interaction zone is optimized. The problem is analyzed here on the basis of the one-dimensional Fourier equation of transient heat conduction and the equation of heat balance in a meltable solid. The solution yields the depthwise temperature profile in the

solid phase prior to melting and the dependence of the efficiency of fusion by one laser pulse on the duration of that pulse at various energy density levels, with correction necessary for build-up of the liquid phase. Numerical calculations have been made for welding 12Cr18Ni10Ti steel with a laser beam, or with any other periodic-pulse heat source such as an electron beam. References 5: 2 Russian, 3 Western.

2415/9716
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UDC 621.791.72:621.373.826

CHARACTERISTICS OF WELDS JOINING PARTS OF HIGH-STRENGTH PIPE STEELS AND PRODUCED BY BEAM OF CONTINUOUS-WAVE CO_2-LASER

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 9, Sep 86 pp 17-18

[Article by E.S. Lurye, engineer, and I.A. Shmeleva, candidate of technical sciences, All-Union Scientific Research Institute for the Construction of Main Pipelines, and V.S. Smirnov, engineer, All-Union Electric Scientific Research Institute]

[Abstract] A study of welded joints between parts of high-strength pipe steels for gas pipelines operating under up to 12 MPa pressure was made, such joints having been produced by a beam of a 2.5 kW continuous-wave CO_2-laser and then tested mechanically by standard methods. Two steels had been selected for this study, a ferritic-pearlitic one hardened by heat treatment and a bainitic one. Plates of the same steel, each 5 mm thick, were welded together by two methods: forming a bilateral seam at a rate of 40 m/h in each pass and forming a composite seam at the same rate with or without Sv-08G2S filler rod. Either pure He or a He:CO_2= 1:1 mixture was used for the gaseous shield. Longitudinal Gagarin specimens were tested in tension for yield strength, ultimate strength, and percentage elongation, in static flexure, and in impact, at temperatures ranging from 20°C to -60°C. The seam in all joints was found to be stronger, also more resistant to brittle fracture at temperatures below -40°C, than the base metal. Use of a filler rod was found to enhance the characteristics of these joints. The results indicate that welding these pipe steels with a continuous-wave CO_2-laser produces better joints than manual electric-arc welding or automatic welding with Sv-08GA filler rod under AN-47 flux. References 4: 2 Russian, 2 Western.

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COPPER BRAZING ALLOYS FOR PRESSURE BRAZING OF CERAMIC TO METALS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 9, Sep 86 pp 27-28

[Article by M.A. Pavlova, engineer, and R.Ye. Kovalevskiy, engineer]

[Abstract] Since brazing with 99.9% pure copper requires heating above 1083°C, nonvolatile copper alloys melting at lower temperatures have been sought for brazing bare ceramic material to metals including copper. Binary alloys of the Cu-Ge system were preferred because of their lower cost than that of alloys containing precious metals. For an experimental comparative evaluation, various alloys of this system with up to 12% Ge as well as a silver alloy and a gold alloy were used for brazing Al_2O_3 ceramics (VK94-1, A-995) to Cu, Mo, Ni, Fe+ 29% Ni+ 18% Co alloy, and 12Cr18Ni10Ti steel under vacuum or in a dry H_2 atmosphere. Analysis of test data on the wetting characteristics and the adhesion strength as well on the flexural strength and the hermeticity of joints has resulted in the preliminary choice of two brazing alloys, Cu+ 8.7% Ge+ 0.5% Ni+ 0.2% B and Cu+ 5.4% Ge+ 1.0% B, beginning to melt at 950°C and 988°C respectively. Substituting up to 1% Mn for B and Ni has been subsequently found to improve the brazing characteristics and the joint so that Cu+ 8.7% Ge+ 1.0% Mn becomes the final choice of brazing alloy for ceramic-metal joints. References: 5 Russian.

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CSO: 1842/22

UDC (621.791.753.5.052:669.15-194.2):621.643:620.162.4

FRACTURE RESISTANCE OF WELDING SEAMS ON GAS PIPELINES 1420 MM IN DIAMETER

Kiev AVTOMATICHESKAYA SVARKA in Russian No 10, Oct 86 (manuscript received 15 Aug 85) pp 9-14

[Article by S.Ye. Semenov, candidate of technical sciences, and S.L. Mandelberg, doctor of technical sciences, Electric Welding Institute imeni Ye.O. Paton, UkSSR Academy of Sciences; V.N. Goritskiy, candidate of technical sciences, and A.S. Bolotov, candidate of technical sciences, All-Union Scientific Research Institute for Trunk Pipeline Construction, and N.I. Anenkov, candidate of technical sciences, All-Union Scientific Research Institute of Natural Gas]

[Abstract] An experimental study of welded joints along large and thick steel pipes was made for a determination of the cracking resistance of the seam, such pipes being used for natural-gas trunk pipelines and the seam having been found to be usually the least impact-resistant element of the joint. Pipe specimens of Kh70 steel 1420 mm in diameter and with 15.7 mm wall thickness, produced at the Khartsyzsk Pipe Manufacturing Plant, were welded together in a triple-arc machine using Sv-10G2, Sv-08GM, or Sv-08GNM electrode rods and AN-60 or AN-65 flux. The hardness of the seam metal did not exceed the usual Vickers 240 number. Two groups of seam were found to have been

produced, with nominal required impact strength and with much lower impact strength respectively. They were tested under internal hydrostatic pressure of 7.5-13 MPa, with the yield point reaching 550 MPa, at temperatures from -60°C to 40°C, and under external dynamic load on DWTT specimens. The cracking resistance was estimated on the basis of the critical width of crack opening at the crack tip under a static flexural load in a 3-point bending test. Crack initiation work and crack propagation work were calculated from the data, the dispersion of data having been found to be smallest for specimens with V-form notches. The results reveal a rather simple direct relation between toughness of the seam metal and width of crack opening at the crack tip as toughness indicator. The relation between crack propagation rate and toughness is more intricate, however, but indicates the requirements for avoiding brittle fracture of welding seam along pipes made of pearlitic low-carbon steel. References: 3 Russian.

2415/9716
CSO: 1842/24

UDC (621.791.754'291.052:669.293):620.18

STRUCTURE AND PROPERTIES OF WELDED JOINTS PRODUCED BETWEEN NIOBIUM PARTS IN CONTROLLABLE HELIUM ATMOSPHERE

Kiev AVTOMATICHESKAYA SVARKA in Russian No 10, Oct 86 (manuscript received 25 Mar 85, in final version 8 Oct 85) pp 21-24

[Article by G.A. Petrunin, candidate of physico-mathematical sciences, A.M. Lyubchik, engineer, and N.F. Chugay, engineer, Metal Physics Institute, UkSSR Academy of Sciences); Ye.A. Asnis, candidate of technical sciences, and M.M. Nerodenko, doctor of technical sciences, Electric Welding Institute imeni Ye.O. Paton, UkSSR Academy of Sciences]

[Abstract] Specimens of 1 mm thick niobium plates were joined by welding in a controllable helium atmosphere for a study of the impact strength of their joints. Some were welded at a rate of 2.8 mm/s with an energy of 140 J/mm and some were welded at a rate of 16.6 mm/s with an energy of 76 J/mm. The joints were tested for microhardness and impact strength of the seam and the thermal influence zone with a PMT-3 hardness tester and with a KM-0.5T swinging pendulum, respectively, after two notches had been cut: one along the seam axis and one 1.5 mm away from it. Disk specimens 3 mm in diameter were cut from joints by the electric-erosion method, then polished with emery paper to 15-20 um thick foils transparent to a 100 keV electron beam and electrochemically with a solution of 2.7 moles/l HCl + 2.7 moles/l HNO_3 for examination under a 100 kV "Tesla BS-513A" electron microscope. A quantitative analysis of the dislocation structure and the stress-strain characteristics based on the data reveals an anomaly of niobium joints, namely an increase of impact strength with decreasing grain size. Accordingly, welding at a higher rate produces stronger joints. The thermal influence zone becomes susceptible to fracture as a result of strain hardening with attendant increase of the dislocation density during the welding process. References 9: 6 Russian, 3 Western (all in Russian translation).

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STRENGTH INDICATORS FOR BODIES COLLILDING IN EXPLOSION-WELDING PROCESS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 10, Oct 86 (manuscript received 13 May 86) pp 35-38

[Article by V.G. Petushkov, doctor of technical sciences, Electric Welding Institute imeni Ye.O. Paton, UkSSR Academy of Sciences]

[Abstract] The strength characteristics of particles colliding in the explosion-welding process are, according to H. Abrahamson, represented in γ, v_c coordinates (γ- collision angle, v_c- velocity of contact point). This concept is based on the hydrodynamic theory, which yields the minimum velocity of the contact point and the "weldability window" along with the lower weldability limit represented by the $\gamma v_c = k\sqrt{HV/\rho} = \text{const}$ line in the range of small γ (ρ- density of metal, HV= p, HV/ρ - equivalent Reynolds number). These parameters, implicitly including the Hugoniot elastic limit as well as the static yield point and ultimate strength, adequately characterize explosion welding of parts made of the same metal. In the case of two different metals, especially metals with widely differing static strength, it is still necessary to ensure a reverse mass flux and therefore to match one of the metal in terms of hardness and density. In this case only a variable coefficient k will reconcile theoretical data with experimental ones, which has no physical basis. The theory of elastic-plastic deformation is added, to deal with both situations, with introduction of dynamic viscosity and yield point as criteria for formation of a wavy boundary during high-speed plastic deformation. References 17: 13 Russian, 4 Western (in Russian translation).

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FRICTION WELDING: ADVANCED METHOD OF PRODUCING END CUTTING TOOL

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 2-4

[Article by V.A. Solovyev, engineer, Elektrosila (LPEO) imeni S.M. Kirov; G.P. Goloviznina, engineer, Sestroretsk Tool Plant imeni S.P. Voskov; E.Kh. Arkhipova, engineer, Bolshevik Plant; and A.Ye. Korchemkin, candidate of technical sciences, Leningrad Mining Institute]

[Abstract] The method of joining the bit and the shank of a point cutting tool by friction welding was introduced at the Sestroretsk Tool Plant in the early nineteen sixties, the tool bit being made of wear-resistant heat-resistant high-speed tool steel (R6Mo5, R6N_2Mo5, R6Mo5Co5, R12, R18) and the shank being made, for economy, of a sufficiently strong and tough plain carbon or structural alloy steel (St45, St50, 40Cr). The pressure of heating air (0.18-0.54 MPa) and the relative rubbing speed (500-1000 rpm) determine the process temperature, which should be 1125-1350°C, and the allowance for

set, another parameter being the heating time (2-20 s). Tool bits 16, 18, 22 mm in diameter, whether for drilling or milling, are welded to shanks in a semiautomatic machine such as the MF-362 which is capable of handling 12-23 mm long bits and 55-140 mm long shanks. Immediately after welding the tools are held in a bin for a while at 600°C without air cooling, so as to ensure high quality and to prevent cracks in the thermal influence zone. Subsequent heat treatment consists of heating to 840-860°C at a rate of 100°C for isothermal anealing for 1-2 h, cooling at a rate of 30°C to 720-730°C and holding there for 4-6 h, then cooling in the bin outside the furnace. The method of friction welding was adopted at the Bolshevik Plant in the 1970s, with the postwelding heat treatment modified to holding at 500°C + heating to 840-860°C within 5-6 h for nonisothermal annealing + holding for 2 h at 840-860°C + cooling in furnace to 500°C. Isothermal annealing is more economical. Friction welding of cutting tools by this method reduces waste of material containing scarce metals and lowers the power requirement, which is especially advantageous in large-scale production of such tools. References 7: 6 Russian, 1 Western (in Russian translation).

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FRICTION WELDING OF TOOL JOINTS TO PIPES FOR GEOLOGICAL AND EXPLORATION DRILLING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 p 4

[Article by V.V. Gusev, Bashneft Production Association]

[Abstract] Friction welding of tool joints to pipes for geological and exploration welding in an MST-2001 machine offers several advantages over butt welding in a UMA-25 machine. Not only is the axial misalignment reduced from 0.95 mm maximum to 0.5 mm maximum, but the power requirement is reduced from 400 to 40 kVA and the productivity is increased from 10 to 25 pcs/h with elimination of internal burrs and noxious fumes. The process has been designed for 3-6 m long pipes with 11 mm wall thickness made of group-D steel (Technical Specification TU 14-3-754-79) and tool joints made of 40CrNi steel with Rockwell Hardness C 28-32 after heat treatment. The impact strength of the welding seam, for operation under cyclic and dynamic bending loads, is increased by heat treatment which consists of high-frequency induction heating in an IZCh-100/8 furnace to 850°C within 90 s. Chuck and jaws of the MST-2001 machine have been specially redesigned. Their life is lengthened by a layer of PG-CrNi80SiB4 self-fluxing powder with Rockwell Hardness C 57-60 on the rubbing surfaces.

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INERTIA WELDING WITH VARIABLE MAGNITUDE OF IMPACT LOAD

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 5-6

[Article by E.S. Karakozov, doctor of technical sciences, Moscow Evening Machine Building Institute; V.I. Kominov, engineer, V.I. Yegorov, candidate of technical sciences, and V.V. Levashov, candidate of technical sciences, Altay Scientific Research Institute of Machine Building Technology Scientific-Production Association, Barnaul]

[Abstract] A machine for inertia welding is described which, in addition to an electromagnetic inertia drive for axial loading, also includes a pneumatic mechanism for axial impact loading. Mounted horizontally opposite each other on the support column are a rotating shaft with axial play and a stationary guide bushing, each carrying at the end a chuck with three jaws for holding, respectively, the rotating part and the stationary part to be welded together. On the shaft behind the chuck are a magnetic core of St3 carbon steel with a copper winding, a flywheel with a clutch, and a sheave for belt transmission to the drive motor. A spring-loaded and pneumatically actuated plunger with striking head travels through the bushing. This machine was tested on blanks of St45 carbon steel 24 or 30 mm in diameter. The electromagnetic drive alone delivered an initial pressure of 25.1-45.9 MPa and a final pressure of 34.1-66.7 MPa, with the flywheel rotating at 4600 rpm. With pneumatic impact added, the plunger striking at a repetition rate of 12 s^{-1}, the initial pressure was 25.1-45.9 MPa and the final pressure was 49.1-119.3 MPa. The set was 0.1-1.7 mm in the first case and 1.6-5.9 mm in the second case. Design analysis indicates that an electromagnetic inertia drive is simpler and more reliable than a hydraulic, pneumatic, or hydropneumatic one. Metallographic examination and hardness measurements indicate that pneumatic impact extends the range of welding capabilities and improves the quality of joints. References: 4 Russian.

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CHARACTERISTICS OF JOINT FORMATION DURING FRICTION WELDING OF Ti ALLOYS TO Nb ALLOYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 6-7

[Article by Academician I.M. Fedorenko, UkSSR Academy of Sciences, V.T. Bondar, candidate of technical sciences, B.D. Buts, engineer, and I.M. Yushchenko, engineer, Institute of Materials Science Problems, UkSSR Academy of Sciences]

[Abstract] Friction welding of the OTi4 alloy (0.1% C, 2.5-4.2% Al, 0.8-2% Mn, 0.15% O_2) to the WNi2N_2E niobium alloy (0.05% C, 0.5-4.7% Mo, 0.5-0.9% Zr, 0.02% O_2, 0.02% N_2) without a shielding medium was studied for structural and

phase transformation during joint formation. Cylinders of the OTi4 alloy 17 mm in diameter and 55 mm long were welded to cylinders of the WNi2N_2-E alloy 15 mm in diameter and 50 mm long, within a time of 2.8-4.0 s with one cylinder spinning at a tangential velocity of 0.7 m/s or 1.2 m/s. Metallographical examination of the seams by x-ray structural and phase analysis revealed a distinct and straight boundary. In addition to (101) α-Ti and (110) Nb forming under higher pressure and speed, with comminution of grains and recrystallization of the Ti alloy, an orthorhombic (Ti,Nb) solid-solution was also found to form under lower pressure and speed with resulting weakening of the joint. References: 7 Russian.

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OPTIMUM DURATION OF STEADY-STATE STAGE IN FRICTION WELDING OF METALS WITHOUT ARTIFICIAL BRAKING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 7-9

[Article by A.S. Seregin, engineer, Siberian Metallurgical Institute imeni Sergo Ordzhonikidze]

[Abstract] An experimental study of friction welding of metals without artificial braking for instantaneous stopping of the machine was made, the advantages being saving of energy and elimination of impact. The optimum duration of the steady-state stage, running at constant speed prior to disconnection of the electric drive motor from the power line and subsequent coasting to standstill, was determined in welding of St3 carbon steels to St3 carbon steel under a pressure of 64 MPa and of R12 tool steel to St45 carbon steel under a pressure of 166 MPa. In the first case both specimens were 14.1 mm in diameter. In the second case the specimens were respectively 8 mm and 10 mm in diameter. Measurements have yielded the dependence of the friction coefficient and the friction power as well as of the set and of the equivalent stress on the duration of that stage, also of the friction coefficient and the friction power on the speed during coasting. The results indicate that the constant-speed stage should be of minimum duration and include the heating period only. Plastic deformation will then occur and a joint will form during the coasting stage. References: 4 Russian.

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CHARACTERISTICS OF INDUSTRIAL FRICTION WELDING TECHNOLOGY

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 9-10

[Article by V.P. Voynov, candidate of technical sciences, N.M. Vedernikov, engineer, and R.N. Bondyrev, candidate of technical sciences, Chelyabinsk Engineering Technological Institute for the Automation and Mechanization of Automobile Manufacture]

[Abstract] The industrial technology of friction welding, approximately optimized for manufacture of any given product, is analyzed on the basis of operation in a large manufacturing plant. Considered as a typical product to illustrate plain friction welding and inertia friction welding is a bimetal valve for an automobile engine, such a valve being produced by welding together a blank of 55Cr20Ni4Mn9N_2 steel and a blank of 40CrNi steel 10.5 mm in diameter each. The process of plain friction welding with a KUKA "RS4" machine (power 20 kW, spindle speed 3000 rpm, maximum axial force 40 kN) consists of five phases: 1. spindle accelerated to full speed without application of axial force; 2. surface of blanks lapped in preparation for heating by friction under light axial force; 3. full axial force applied; 4. drive motor disconnected - brake actuated and then disconnected before spindle has come to a standstill - light axial hammering force applied; 5. full axial hammering force applied for better balance of axial and torsional plastic strains (with "chilling" and stress relieving for two blanks of the same structural steel). In inertia friction welding with a Caterpillar "DUAL 60" machine phase 1 is much more precisely controlled, in terms of spindle design (moment of inertia) and spindle operation (initial speed), while phases 2, 3, and 4 are combined and phase 5 is essentially the same as in plain friction welding. References: 2 Russian.

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PRODUCING PERMANENT JOINTS IN MEDIUM OF FUSIBLE METALS WITH SIMULTANEOUS DEPOSITION OF DIFFUSION COATINGS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 11-13

[Article by A.G. Sokolov, candidate of technical sciences, and T.I. Ivanova, doctor of technical sciences, Leningrad Mechanical Institute imeni Marshal of the Soviet Union D.F. Ustinov]

[Abstract] Formaton of a permanent welding seam between parts by a melt of fusible metal containing a dissolved refractory metal is based on isothermal directional transport of the refractory metal through the melt, a coating of the refractory metal being simultaneously deposited on the surfaces of both parts as a result of interdiffusion. This technology has been developed for and tested on parts made of the same material (St10 plain carbon steel, St45

plain carbon steel, Nb alloy, Mo alloy) as well as for parts made of different materials (U7 shock-resistant steel + 12Cr18Ni10Ti stainless steel, St45 plain carbon steel + R6Mo5 high-speed tool steel, St10 or St45 plain carbon steel + Nb alloy or Mo alloy). Use of a Pb-Ni melt as medium has resulted in high-strength joints, with both process temperature and time optimized for any given pair, with proper surface finish and clearance between parts. The method is applicable to production of butt, lap, and telescopic joints with diffusion coatings. References: 3 Russian.

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UDC 621.791.011:(669.715+669.74)

ENSURING HIGHER STABILITY OF IMMERSED-ARC WELDING OF STRUCTURAL ALUMINUM ALLOYS AND MAGNESIUM ALLOYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 10, Oct 86 pp 13-14

[Article by A.F. Nesterov, candidate of technical sciences, Ye.A. Bulgachev, candidate of technical sciences, and N.B. Boytsov, engineer, Moscow Aviation Technological Institute imeni K.E. Tsiolkovskiy]

[Abstract] Welding together 5-60 mm thick parts made of Al alloys or Mg alloys with a nonconsumable electrode and an immersed arc can be done in a single-pass operation not requiring a filler rod, but requiring continuous maintenance of a constant arc voltage. This is achievable by vertical movement of the electrode or by regulation of the welding current depending on the magnitude and the sign of the difference between arc voltage and reference voltage. An experimental study of this process has established that proper selection of the reference voltage is the decisive factor ensuring high stability. The optimum reference voltage for welding with currents of 100-800 A at speeds of 6-24 m/h was determined in series of tests with arc immersion depth maintained constant within ±0.2 mm and with the reference voltage varied in 0.25 V steps at any given fixed welding current and speed. Since the arc voltage depends on the electrode immersion depth, the electrode tip must be shaped for maximum process stability. References 4: 3 Russian, 1 Western.

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UDC 621.791:658.5.011.46

AN ADJUSTIVE AUTOMATED PROCESS-CONTROL SYSTEM FOR ARGON-ARC PIPE WELDING

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 1-3

[Article by N.A. Shirkovskiy, engineer, E.A. Gladkov, doctor of the technical sciences, P. V. Polyanskiy and O.N. Kiselev, engineers, N.E. Bauman Higher Technical School, Moscow]

[Abstract] Research was done to determine whether an automated process-control system can be used to compensate for external factors not under direct control during the welding process. A mathematical model was constructed to represent the heat field in the welded object and to show how the various external factors affect temperature field parameters. These parameters were calculated as a function of: ideal thermal efficiency, thickness of the material, welding speed, the coefficients of volumetric heat and thermal diffusivity, and the constant distributive time of the welding heat source. These functions were calculated under the following conditions: coefficient of the material's thermal diffusivity, 0.07 cm^2/s; the coefficient of the material's volumetric heat, 6.28 $J/(cm^3 \cdot °C)$; constant times representing degree of heat source distribution, 1 and 0.1 s; arc power, 8500 W; eta=0.85; I=500 A; U=20 V; welding speed, 5 cm/s; layer thickness=25 cm. The given temperature was 800°C. The calculations showed that changes in the parameters that determine linear energy and in the coefficient of volumetric heat lead to identical changes in the width of the welding seam and the reverse-side weld and in the temperature of a fixed point in the welding seam. Thus the external factors not directly controlled during the welding process can be adjusted for using information on the two parameters of the superficial heat field. From these parameters, a criterial parameter is obtained that reflects the effects of specific external factors. On the basis of the model, an algorithm was formulated that allows an automated process control system to compensate for non-controlled external factors. References 3: 2 Russian, 1 Western.

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CSO: 1842/40

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THE COMPONENTS AND HARDWARE IN AN AUTOMATED PROCESS-CONTROL SYSTEM FOR ARGON-ARC PIPE WELDING AND AN EVALUATION OF THE EFFICIENCY OF THE SYSTEM'S OPERATION

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 3-5

[Article by E. A. Gladkov, doctor of the technical sciences, and N.A. Shirovskiy, P.V. Polyanskiy and O.N. Kiselev, engineers, N. E. Bauman Higher Technical School, Moscow]

[Abstract] Specialized hardware for an automated process-control system for argon-arc pipe welding was developed from series-produced components complemented by specialized devices. The measuring subsystem consists of a power supply shunt, which outputs data on welding current to a scaling

amplifier and a low-frequency filter (LFF); a scaling resistor divider and LFF measure voltage; a photoimpact sensor measures the skelp's rate of travel and sends the signal to a frequency-voltage converter; a contact-type thickness gauge with a current-voltage converter; a water-jacketed pyrometer mounted on a guiding device; a TV camera to track the seam and a TV monitor; and a circuit board to segregate the signal on the width of an overheated seam zone. The measuring data is input to an Elektronika DZ-28 computer. The user interface consists of a terminal with a keyboard and a thermoprinter, and a graph plotter. An analogue controller built as a five-channel summator controls the welding process. Each channel contains a setting-control device and is controlled by the digital code of the voltage divider. The welding-current control subsystem consists of a rectifyer with a thyristor regulator controlled by a floating current stabilization system mounted inside the power supply. The entire process control system is run by software in BASIC. The user can choose from a menu of six programs: Program 1 allows the user to call up the welding data. Program 2 allows the user to query the sensors, with this data automatically sent to the computer. Programs 3 through 6 allow the user to control various welding variables such as welding speed, consistency of seam width and depth, and the coefficients for automating the regulation of the welding process. When tested on a TESA20-76 welding apparatus, the automated system helped to improve the efficiency of the welding process at least 35%.

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AN ARGON ARC-WELDING PROCESS-CONTROL SYSTEM BUILT AROUND AN ELEKTRONIKA-60 MICROCOMPUTER

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 8-9

[Article by B.N. Badyanov, doctor of the technical Sciences, O.V. Belyakov, engineer, and V. A. Davydov, candidate of the technical sciences, Moscow Electronic Machine Building Institute]

[Abstract] The Moscow Electronic Machine Building Institute has developed a system for controlling argon-arc welding processes. The system contains an Elektronika-60M microcomputer, power packs, a converter unit, a PIU-2 display unit, a Consul 260 electric programming machine, and an FS-1501 optical scanner. Welding current, arc voltage, and welding speed data are put out by sensors on the welding apparatus. Welding current is calculated from the voltage drop on the measuring shunt. Arc voltage is measured directly in the gap. Welding speed is regulated by controlling the revolution frequency of the drive motor shaft, utilizing a series-produced VYe-187-1000 sensor. A relaying cut-off circuit protects the converter input circuits when the power source is idle. Dual integration converters with good noise suppression and good measuring accuracy are used for analog-to-digital conversion. The minimum measuring time is 0.1 s. The speed meter counts the number of pulses coming from the sensor within a known time interval. The computer used this data to calculate the linear rate of travel of the arc along the weld seam and the

length of seam completed. The time module, which controls the converters and meters, used a quartz reference frequency generator that is very accurate and reliable. The measuring cycle meter monitors real time from the moment the welding arc is ignited and inputs the measurements to the computer, which operates in a hunt mode. The measuring converters operate cyclically and independently of the computer in order to ensure that maximum data is gathered during real time. References: 2 Russian.

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THE TECHNICAL FEASIBILITY OF USING SPIKED-RADIATION LASERS TO CUT OUT AND WELD METALS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 14-15

[Article by A.G. Grigoryants, doctor of the technical sciences, A.I. Belunik and A.B. Yeliseyev, engineers, I.N. Shiganov and R. Sh. Zagidullin, candidates of the technical sciences, N.E. Bauman Higher Technical School, Moscow]

[Abstract] A one-dimensional model for heat distribution in a semi-infinite body was used to calculate the process of heating a metal plate with a train of evenly spaced spiked laser radiation pulses. The effect of the integrated envelope of a spiked radiation pulse on the temperature field in the metal was also analyzed. It was established that heating metal with spiked pulses is more efficient than using constant-intensity pulses. An LTN-102 laser, which can generate these types of pulses, was used experimentally to cut and weld St3, 39KhGSA, and other steels. The active component of the LTN-102 is an ittrium-aluminum garnet (6.3X100) containd in a K-301V quantron. A Fabri-Pero (Great Britain) scanning interferometer is the basic component of the resonator Q-factor modulator. An FEU-62 detector is located behind a semi-transparent mirror for the purpose of visualizing the temporal structure of the radiation pulse. The signal from the detector goes to an oscillograph. The laser generates the most radiation pulses between 20 and 60 Khz. During the tests, the specimens were subjected to an average radiation intensity of 100 W. The radiation was focused on the surface of the metal through a lense with a focusing distance of 0.05 m. The convergent aperature was $1.5 \cdot 10^{-3}$ m. The cutting emission was $5 \cdot 10^{-4}$ m. The spike modulation frequencies were 20, 35, and 60 Khz, and spike length was $2 \cdot 10^{-6}$ s. The use of spiked radiation pulses had a wide range of applications and can increase efficiency 25% to 30%. References: 2 Russian.

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DIFFUSION WELDING OF ALUMINOMAGNESIUM ALLOYS TO CERAMICS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 17-19

[Article by V.A. Bachin, candidate of the technical sciences, E.A. Goritskaya and I. Ye. Tikhonova, engineers, K. E. Tsiolkovskiy Aviation Technological Institute, Moscow]

[Abstract] The formation and development of interaction loci during the diffusion welding of aluminomagnesium alloys and polycrystalline polycor and monocrystalline sapphire was studied. The tests were performed on ceramic plates polished and pickled in boiling orthophosphate acid with subsequent vacuum annealing ($1.33 \cdot 10^{-3}$ Pa) at 1973 K. The ceramic plates were welded to A7 aluminum foil (10 MPa, 913 K, 60 minutes for polycor; 8 MPa, 913K, 40 minutes for sapphire), AMg6 alloy foil (10 MPa, 873 K, 20/90 minutes for polycor; 8 MPa, 893 K, and 40 minutes for sapphire), and MA2-1 alloy (10 MPa, 873 K, and 10/40 minutes for polycor; 8 MPa, 853 K, 40 minutes for sapphire). After the materials were welded, the metal was stripped off in a boiling 20%-solution of NaOH. Examination with an electron microscope showed that, in the case of the polycors, interaction started primarily along grain boundaries and in porous areas. Higher concentrations of magnesium were associated with more intensive interaction. When aluminum foil was welded to sapphire, the aluminum hydroxides decomposed, and an amorphous film of aluminum oxide crystallized into a gamma phase. When alloy foil was welded to sapphire, there occurred a substitutional reaction of magnesium for aluminum in the sapphire. The interaction loci were uniformly distributed over the entire surface of the sapphire backing. Welding MA2-1 to sapphire showed that the topochemical reaction can convert to a reaction involving the formation of a low-fusion point gamma phase of Mg_4Al_3 at 735 K. Tests of the weld joints were performed on hollow cylinders (diameter 20 mm, bore 16 mm, length 60 mm) to determine flexural strength. The strongest joints were achieved using AMg6 and relatively moderate welding conditions. References 4: 3 Russian, 1 German.

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THE EFFECT OF HEAT TREATMENT ON THE PROPERTIES OF TUNGSTEN-FREE DIE-SURFACING STEEL

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 25-26

[Article by V.M. Karpenko, B.A. Brusilovskiy and I.I. Gunko, candidates of technical sciences, Kramatorsk Industrial Institute]

[Abstract] The effect of heat treatment on the properties of 80Kh5GZS2R steel, developed for the purpose of hard-surfacing cold dies, was studied.

Thermit welding was used to hard surface specimens with powder filler in copper molds on an ABS unit utilizing a VS-600 power source. The specimens were annealed at 950°C, hardened in oil from 950° and 900°C at a rate varying from 50° to 1200°C/h, and tempered at 500°C. A Chevenard dilatometer was used to construct the thermokinetic diagrams. Impact strength was determined on unnotched specimens 10X10X55 mm cut out of the hard facings. Wear resistance was determined from the loss ratio obtained by abrading 20X20X5 specimens of the surfacing steel and a U8 steel standard after hardening and tempering. Microstructure was studied on an MIM-8 microscope. X-ray phase analysis was performed on a DRON-0.5 diffractometer in Fe-radiation. The optimal annealing conditions involved heating to 950°C for two hours, cooling to 785°C, maintaining this temperature with slight fluctuations above and below it for three to five hours, and then letting the furnace and metal cool down together. The optimal combination of impact strength (0.33 MJ/m^2) and hardness (58-59 HRC) were obtained with a hardening temperature of 900°C and tempering at 500°C. The durability of tools surface-hardened with the new steel and with the widely used 60Kh6V7MF and Kh12M steels was compared in the production of various types of nuts. The criterion was the mass of nuts produced before the dies wore out. Dies surfaced with the new steel were 1.5 to 2.5 times more durable and were also less expensive than the conventionally surfaced dies. References: 3 Russian.

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THE EFFECT OF SURFACE TENSION IN THE WELD POOL ON SEAM FORMATION WHEN WELDING THIN SHEET WITH LIGHT RAYS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 33-35

[Article by S. A. Fedorov, candidate of the technical sciences, and V.V. Ovchinnikov, engineer]

[Abstract] The relationship between welding temperature, surface tension in the weld pool, and the final shape of the weld seam was studied. St3, 30KhGSA, 20Kh13, and 12Kh18N10T steels, OT4 titanium alloy, industrial-grade NP2 nickel, and M1 copper were welded on an experimental apparatus consisting of a xenon arc lamp and a close-focus ellipsoid reflector 300 mm in diameter made of aluminum alloy. Current was 140-150 A, voltage 33-34V, and welding speed 5-20 meters/h. The displacement of the metal in the weld bath was studied by tracking the motion of chromium oxide particles with high-speed photography. Apparently, there is a direct relationship between the temperature of the weld pool, surface tension, the rate and direction of travel of the metal in the weld pool, and the final shape assumed by the weld seam. The displacement in the surface layer of the weld pool was attributed to the difference in surface tension between the head and tail of the bath. Surface tension, in turn, was shown to be a function of overheating of the head of the weld pool. The final shape of the weld seam (thick at the edges and thin in the middle, or properly formed) was a function of the speed and displacement of the metal in the weld bath. By reducing the overheating temperature and the temperature coefficient of surface tension in the metal, the displacement of the surface layer of the bath was mitigated and a more uniform weld seam

obtained. A device that was constructed for this purpose was tested on the steel. The device worked by directing a stream of protective gas onto the weld zone at an angle to the surface and in a direction opposing the displacement of the weld pool. Overheating and rate of displacement were reduced to 1.5 to twofold. References: 9 Russian.

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THE USE OF PHOTOELASTIC METHODS TO STUDY THE STRESSED STATES OF SPOT-WELDED JOINTS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 11, Nov 86 pp 38-40

[Article by V.F. Kozhevnikov, candidate of the technical sciences, and N.M. Kolbin, engineer]

[Abstract] The stressed states of full-scale visual models of spot-welded joints and of an actual spot-welded specimen were studied and compared to see whether a visual model can be utilized to analyze stress distribution in welded objects. The full-scale model was constructed by "welding" together two plys of conventionally made optically sensitive ED-16MA material 1.4 mm thick. The "weld" joints were simulated by dots of epoxy adhesive applied by dipping wire of the required diameter a certain depth into the adhesive and then depositing it where the weld joint was to be formed. The sheets were then pressed tightly against one another, taking care that the joints were aligned. When the adhesive had cured, uniform tensile stress was applied and the resulting deformations "frozen" in a thermostat. The specimen made with actual spot-welded construction was made of sheets of D19 alloy two mm thick. A photoelastic coating of the same material used in the model was applied to one of the surfaces of the specimen. The tensile stress was applied to the faces of the specimen with non-eccentric force. The stress distribution data from the model and the specimen were then compared. The data coincided very closely. Therefore, "frozen" visual models of spot-welded objects can be successfully utilized to analyze the stressed states of actual spot-welded objects. References 6: 4 Russian, 2 Western.

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GRAVITY CONCENTRATION OF MANGANESE ORE AT CHIATURMARGANETS PRODUCTION ASSOCIATION

Tbilisi ZARYA VOSTOKA in Russian 30 Oct 86 p 1

[GRUZINFORM article: "These Rich 'Poor' Ores"; first paragraph printed in boldface in original]

[Text] A new ore concentration technology will help Chiaturmarganets Production Association workers to increase the yield of high-quality concentrates for the metallurgical industry while simultaneous increasing their manganese content.

The new technology, developed by local specialists together with the Georgian Polytechnical Institute imeni V.I. Lenin, will permit an annual production of about 200,000 tons of high-quality concentrate from low-grade ore.

"The consumption of manganese ores increases every year," says A. Khobua, chief engineer of Chiaturmarganets. But, of course, this growth cannot continue indefinitely. Man's economic activity results in depletion of resources, an increase in areas occupied by mining, and contamination of the environment by industrial wastes. All this has already grown to problems that affect all mankind. Also at the Chiatura deposit, which has been worked for over 100 years, we have encountered the problem of the gradual disappearance of so-called oxide ores, which are used at metallurgical enterprises in the production of high-strength metal alloys.

We consider the mastering of the progressive method of ore concentration by "washing out" valuable raw material from the rocks, which is so necessary in the production of metal, an important step towards the solution of these problems. With this method, low-grade ores are concentrated to 50 percent manganese content and are successfully used in the metallurgical industry.

The first batches of concentrated ore have already been produced at leading Chiatura mines--the Lenin mine, the Kalinin mine, and the Pataridze mine. Their mining and concentration by the gravitation method was entrusted to leading brigades headed by experienced miners P. Chitadze and G. Bakradze. Together with a group of specialists headed by the deputy chief beneficiation engineer of the Chiaturmarganets Association, Sh. Grigalashvili, they successfully completed their task.

The conclusions of the Rustavi Metallurgical Plant and the Zestafoni Ferroalloy Plant have confirmed the high quality of the manganese produced by the new technology.

The construction of production capacities designed to produce 10,000 tons of concentrate a year by the gravity method has begun in Chiatura. Their commissioning is planned for next year.

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